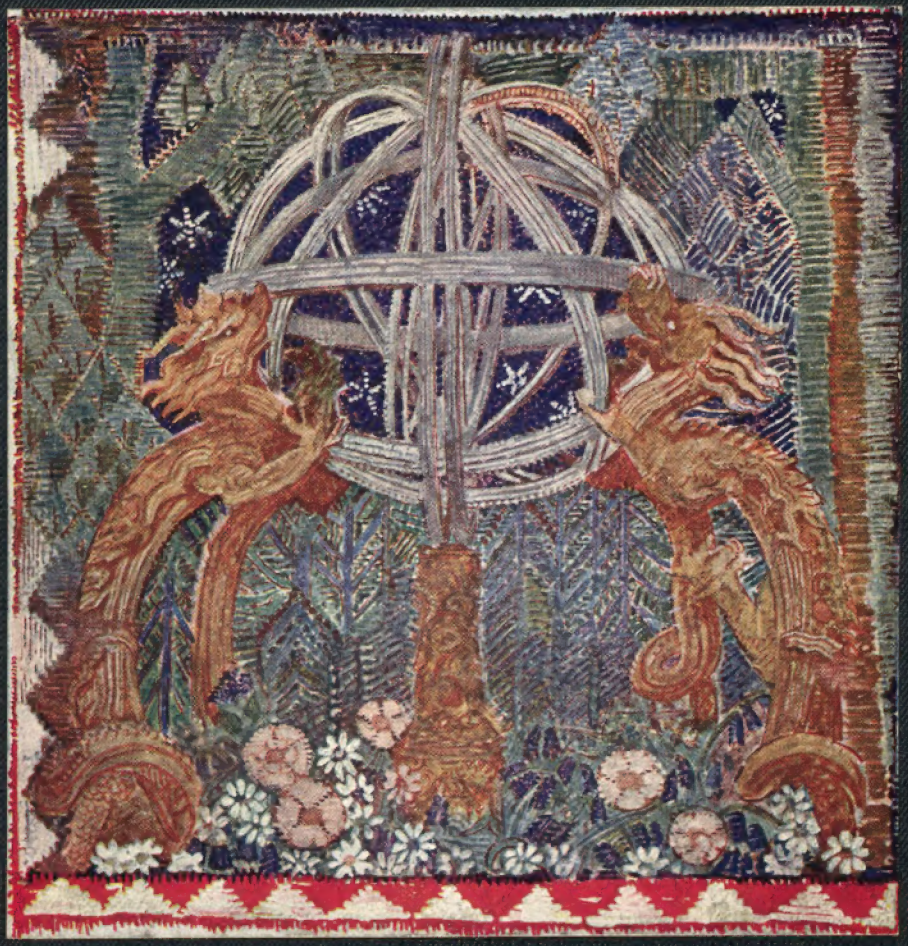
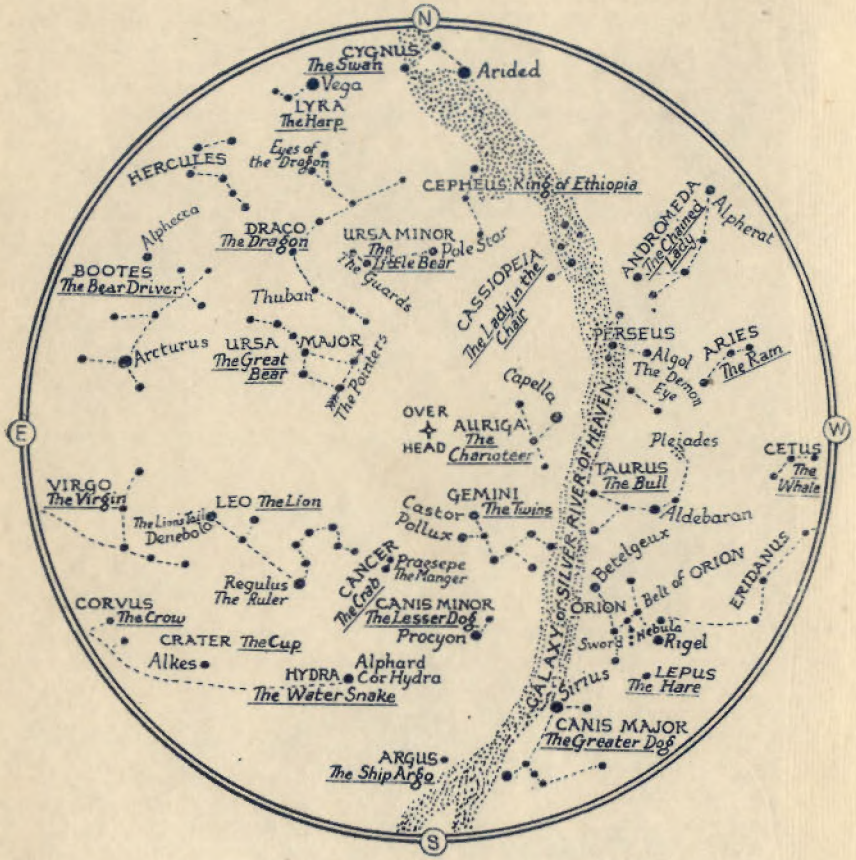
The Book of the Heavens

Mary Proctor

HARRAP

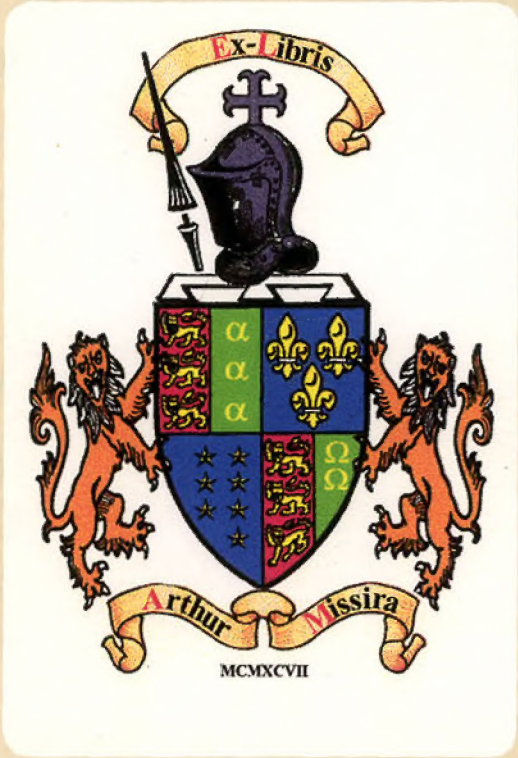
The Book of the Heavens





STARS VISIBLE IN SPRING-TIME

STARS VISIBLE IN SUMMER-TIME



THE BOOK OF THE HEAVENS

ROMANCE OF KNOWLEDGE SERIES

THE BOOK OF THE HEAVENS

By Mary Proctor, F.R.A.S., Author of *Legends of the Sun and Moon*, etc. With 4 Colour Plates, 32 Full-page Half-tone Illustrations, and many Line Drawings. 268 pages.

THE BOOK OF DISCOVERY

By T. C. Bridges, Author of *The Book of Invention*, etc. With 8 Colour Plates, 32 Full-page Half-tone Illustrations, and many Line Drawings. 288 pages.

THE BOOK OF MYTHS

By Amy Cruse, Author of *The Book of Epic Heroes*, etc. With 8 Colour Plates, 32 Full-page Half-tone Illustrations, and many Line Drawings. 288 pages.

THE BOOK OF INVENTION

By T. C. Bridges, Author of *The Book of Discovery*, etc. With 4 Colour Plates, 32 Full-page Half-tone Illustrations, and many Line Drawings. 288 pages.

THE BOOK OF OTHER LANDS

By Dorothy Margaret Stuart, Author of *The Boy through the Ages*, etc. With 4 Colour Plates, 40 Full-page Half-tone Illustrations, and many Line Drawings. 304 pages.

THE BOOK OF EPIC HEROES

By Amy Cruse, Author of *The Book of Myths*, etc. With 8 Colour Plates, 32 Full-page Half-tone Illustrations, and many Line Drawings. 318 pages.

THE BOOK OF ENGLISH VERSE

Being a Treasury of Verse for School and Home. Compiled by M. G. Edgar and Eric Chilman. With 8 Colour Plates and 14 Line Drawings. 524 pages.

THE BOOK OF THE SEA

By T. C. Bridges, Author of *The Book of Discovery*, etc. With 4 Colour Plates, 32 Full-page Half-tone Illustrations, and many Line Drawings. 286 pages.

THE BOOK OF POLAR EXPLORATION

By E. L. Elias, M.A., Author of *Abraham Lincoln*, etc. With 4 Colour Plates, 32 Full-page Half-tone Illustrations, and many Line Drawings. 302 pages.

THE EARTH SEEN FROM THE MOON'S APENNINES
Evelyn Paul
Fr. [*P.* 57]

THE BOOK OF THE HEAVENS

BY

MARY PROCTOR F.R.A.S. F.R.MET.S.
(DAUGHTER OF THE LATE RICHARD A. PROCTOR)
AUTHOR OF "STORIES OF STARLAND" "LEGENDS OF THE STARS"
"LEGENDS OF THE SUN AND MOON" ETC.

WITH ONE HUNDRED AND TWENTY
ILLUSTRATIONS

GEORGE G. HARRAP & COMPANY LTD.
LONDON BOMBAY SYDNEY

First published September 1924
by GEORGE G. HARRAP & Co. LTD.
39-41 *Parker Street, Kingsway, London, W.C.*2
Reprinted February 1926

Printed in Great Britain by Neill & Co. Ltd., Edinburgh

DEDICATED
TO
DAVID THACKERAY
OF ENGLAND
SHERBURNE WESLEY BURNHAM, JR.
OF U.S.A.
EDWARD GIFFORD
OF NEW ZEALAND

Thus some who have the Stars survey'd
Are ignorantly led
To think those glorious Lamps were made
To light Tom Fool *to bed.*

NICHOLAS ROWE

PREFACE

THIS book is written for boys and girls, perhaps more easily to be interested in the wonders of the heavens than their elders, who are too busily absorbed on our minute planet Earth to find time for 'star-gazing,' as they sometimes slightingly term it.

Some of my readers may become great astronomers; for that reason I have woven in accounts of my visits to some leading observatories of the world, that boys and girls may see astronomers of to-day at work. I have endeavoured to create a thirst for further knowledge of the celestial universe through which our tiny globe is travelling, and I shall be amply repaid for the pleasant labours I have expended upon my book if I am successful in this, if only in a few cases.

I am greatly indebted to the Astronomer Royal and to the Directors of the Yerkes, Lick, and Mount Wilson Observatories for permission to use the illustrations which are acknowledged in the inscriptions thereto as printed from their photographs; to Messrs Sir Isaac Pitman and Sons, Ltd., for permission to use the various drawings and diagrams in the text acknowledged as from Sir Robert Ball's *In Starry Realms* and *In the High Heavens;* to the publishers of Allen's *Star Names and their Meanings,* Messrs G. E. Stechert, for permission to print the poem by Edith M. Thomas entitled " Winter Street "; and to Messrs Chatto and Windus for permission to use the star-drift charts from *Easy Star Lessons,* by R. A. Proctor. I have also to thank the Director of the Dominion Observatory, Victoria, B.C., for the use of illustrations from photographs duly acknowledged.

MARY PROCTOR

CONTENTS

ILLUSTRATIONS

Book of the Heavens

Illustrations

THE BOOK OF THE HEAVENS

CHAPTER I

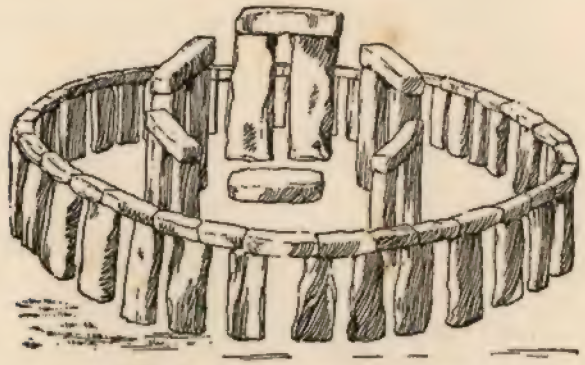
THE STORY OF THE SUN

IN the days of old people believed that the Earth was flat, and that it floated on the surface of an ocean without limit. The sky was a blue canopy resting on the tops of lofty mountains behind which the Sun disappeared at sunset. We can imagine the anxiety with which the earliest watchers of the sky waited for its return to cheer them with its light and warmth next day.

THE EYE OF HEAVEN

Naturally they wondered whither it went during the long night hours, and the Greeks invented wonderful stories about the Sun, which they believed to be a god. He was supposed to disappear at sunset through the western gate of the sky leading to the dark Cave of Night. Here he encountered numberless foes, performed wondrous deeds of prowess, slaying dragons and mighty monsters, finally

emerging triumphant at the hour of dawn. As the golden-haired Apollo, he drove his glistening chariot across the sky, always vanishing at sunset in a blaze of glory. Vulcan awaited him with his barge, rowing him across the Underworld, and bringing him to the eastern gate of the sky at dawn, after his nightly struggle with the demons of darkness.[1]



RECONSTRUCTION OF STONEHENGE

Sometimes when the Sun-god was angry he withdrew his light behind the clouds, but when he was pleased he beamed in magnificent splendour. Such a god must be appeased, so prayers and sacrifices were offered to him daily in temples erected in his honour. Ruins of these temples are to be found in Egypt, Syria, Rome, and elsewhere. The circular group of stones at Stonehenge, which is a cause of wonderment to all who visit it, is connected with the worship of the Sun-god in Britain by the Druids in bygone days. At dawn on the 21st of June many visitors to Salisbury Plain meet to see the Sun rise exactly over the centre of the stone known as 'the Pointer.' It is believed that the Sun-worship

[1] See *The Book of Myths*. In Persia the Sun was worshipped as the bearer of light and chief enemy of demons. He was the Eye of Heaven, and is represented as driving in a bright chariot drawn by celestial horses.

MEN OF THE STONE AGE WORSHIPPING THE SUN

Nancy Smith

THE GREY WOLVES PURSUING THE SUN AND MOON
J. C. Dollman

of the Druids was brought into England by Egyptian colonists, as the rites of the Druids are very like those attached to Sun-worship in ancient Egypt.

But the Sun temples in Peru are said to have been more magnificent than those of any other nation. The principal temple at Cuzco was known as 'the Golden Palace,' for its inner and outer walls were covered with plates of pure gold, the vases and temple ornaments were of the same precious metal, and above the altar was a golden disk with a face engraved on it to represent the Sun-god, and the surface was studded with precious stones. At the hour of dawn the doors opening to the east were thrown wide open, so that the first rays of the rising Sun fell upon its brilliant surface. As they were reflected in dazzling splendour, the Peruvian worshippers imagined that they were looking upon the face of the Sun-god himself.

Around the sacred disk were grouped mummies of the departed kings seated on golden thrones, so that the rays of the morning Sun came day by day to bless their remains. The surrounding buildings were dedicated to other gods. One was sacred to the Moon, the wife of the Sun, and she was represented by a silver disk. Around this were grouped mummies of the ancient queens. Others of the lesser temples were dedicated to the planet Venus, to lightning, and to the rainbow. Outside the temple was a garden filled with beautiful flowers, and imitations of trees, bushes, and flowering shrubs, as well as animals, wrought in solid gold. One can imagine how they must have glistened in the brilliant sunlight of Peru.

Now all this may sound childish, but to the ignorant the daily return of night and day, sunrise and sunset, the chilliness of night replacing the warmth of day, were happenings of great moment. How wonderful must the first sunset ever seen have seemed to the first man! He saw the Sun sink below the horizon and darkness close

in upon the earth; he felt the chill of night and fell asleep not knowing of a sunrise to come. Surely joy and gratitude beyond measure must have overwhelmed him when he found sunlight and warmth awaiting him at dawn!

Little did he know that this old Earth as it turns round and round, so that first one side and then the other is illumined and warmed by the Sun's rays, was

THE ROUND OF NIGHT AND DAY

responsible for the daily round of night and day. Nor had he the remotest idea that the Sun was a star, like any of the myriad stars he saw twinkling in the sky at night, but so much farther away that they appear only as points of light.

Now why is it the Sun appears so much larger than the stars? It is simply because we are by comparison close to it, while the stars, as we shall see later, are placed at enormous distances from the Earth. Even so, the Sun is nearly ninety-three million miles away. It is difficult to realize what this vast distance actually means. If one were to try to walk such a distance, supposing that he could walk four miles an hour, and keep it up for ten hours every day, it would take 68½ years to cover a

million miles, and more than 6,300 years to complete the journey. A cannon-ball moving at the rate of 1,700 feet a second would require nine years for the journey, and the sound of the explosion would not arrive until five years later. It would have distressed the Sun-worshippers of old had they been told that the *sound* of their prayers would require some fourteen years to reach the ears of their Sun-god.

If a child had an arm long enough to reach from the Earth to the Sun and amused itself, while a babe in the cradle, by touching the surface of the Sun with the tip of its finger, it would never know that it had burned its finger. The sensation of pain would require one hundred and fifty years to travel from the child's finger to its brain, so that the child would grow up to manhood and old age and would die without realizing what had happened in its infancy.

This illustration was worked out one evening several years ago by Professor Mendenhall and Professor Young. They were having a learned talk about the Sun when a little boy in the room, seeing a moth hovering near a lamp on the table, tried to save it from destruction. Unfortunately he burned his finger in the attempt, and the professors were disturbed by his cries. While one—the father of the boy—comforted the little sufferer, the other made a calculation to find out how long it would have taken the boy to realize that he had burned his finger had he done so by touching the glowing surface of the Sun.

Now that we have gained some idea of the vast distance separating the Earth from the Sun, let us take an imaginary trip to the Sun by means of an aeroplane travelling at the rate of one hundred and fifty miles an hour. It will have to be a non-stop trip, recalling a story told by Sir Robert Ball, many years ago, at a lecture to children at the Royal Institution:

"I recollect some time ago a picture in *Punch* which

showed a train about to start from London to Brighton, and the guard walking up and down announcing to the passengers the alarming fact that 'This train stops nowhere.' An old gentleman was seen vainly gesticulating out of the window and imploring to be let out ere the frightful journey was commenced."

In the trip to the Sun such a warning to the passengers will not be out of place, and nervous folk had better stay at home. A fond farewell should be made to all our friends and relatives, as we need never expect to see them again. If the aeroplane keeps up the rate of speed of one hundred and fifty miles an hour from start to finish, it will be over seventy years before we finally arrive at our destination, not to mention that the intense heat of the Sun as we draw near to it will scorch the aeroplane and its cargo of passengers into cinders.

However, we are to take the trip in the aeroplane named *Imagination,* and the time required for the journey may be as brief as we like, for in a moment we can span the vast distance on the Wings of Thought. Thus, as we have fitted our aeroplane with these wings, the journey is to be made safely as well as swiftly.

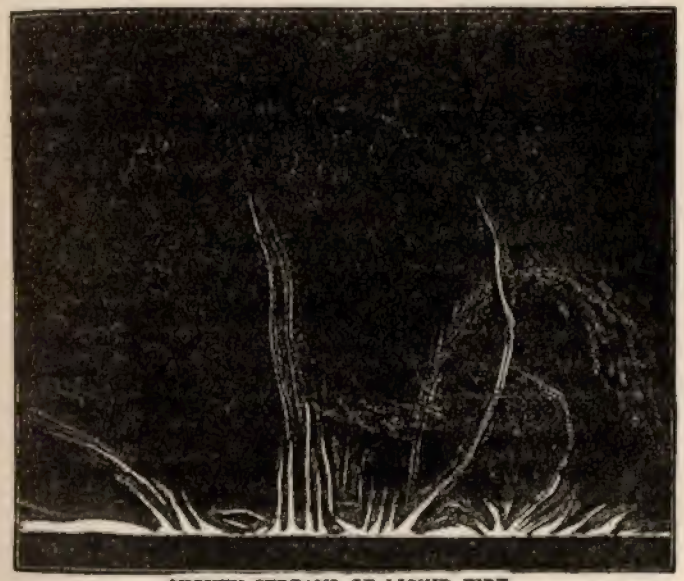
Let me sit in front at the look-out window, so that I can tell you exactly what is ahead of us. First of all we must have our torchlights ready, as after plunging through the blanket of air surrounding our planet we shall find it darker than the blackest night. And talking of blankets, we would need, if we were going by any other conveyance than *Imagination,* a very plentiful supply, as it is bitterly cold in the Ocean of Space.

All our preparations are now ready, and the order is given to start. Up we go, higher and higher, leaving the little old World behind us, until it looks like a silvery ball floating among the clouds which form part of its atmosphere.

We soon find we are being

Pelted with star-dust, stoned with meteor balls,

but they leave us unharmed, as *Imagination* laughs at such trifles. We are able to see some very pretty displays when a meteor goes too near the Earth, and gets trapped in the atmosphere. It is tearing along at such a terrific rate—about twenty-five miles a second—that it cannot stop, and we see a brilliant flare-up as it



MIGHTY STREAMS OF LIQUID FIRE

From "In Starry Realms," by Sir Robert Ball

dashes into aerial particles. *Pouf!* In a moment it is consumed, and vanishes in a trail of light.

We dash by Venus, but miss Mercury, as it is too far away on the other side of the Sun, and finally as we draw nearer and nearer to the Sun we are almost deafened by the uproar on its surface, compared with which the roar of the hurricane, the crash of the thunderbolt, multiplied a millionfold, would seem but a whisper. We have to pilot our craft carefully amid gigantic flames thousands of miles high, reaching upward from the

ocean of glowing vapours surrounding the Sun. No wonder the display has been described as like " a prairie on fire."

Drawing still nearer to the Sun, and winding in and out amid the flames—though by rights we should have been shrivelled up by them long ago—we find the cause of the deafening uproar. We are looking down on vast upheavals in an ocean of glowing vapour as deep as the Atlantic is broad. Mighty streams of liquid masses are tossed to and fro, flung upward to a height of thousands of miles, and they fall back in a drenching spray of molten metals, amid clouds of zinc-steam, iron-steam, and all the many kinds of steam produced by the intensely heated liquid metals on the Sun.

A bewildering sight reveals itself to our dazzled eyes, which are fortunately covered with just the right kind of asbestos goggles necessary for such an expedition. We have come to the edge of one of the great hollows resembling whirlpools which form in the fiery ocean astronomers call the photosphere. The hollows, which are usually referred to as sunspots, are vast enough in many cases to engulf a score of globes as large, or rather as small, as our planet Earth.

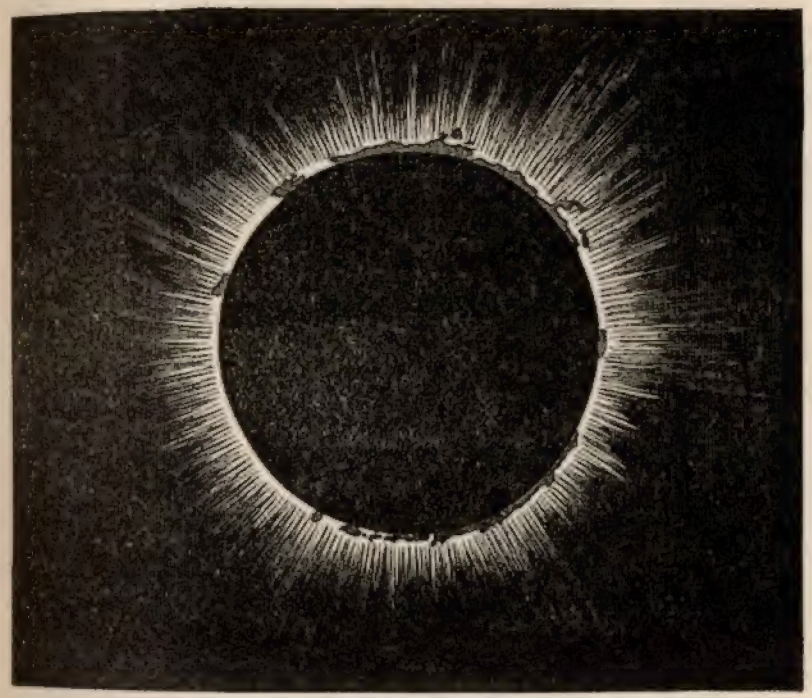
While we are looking into our particular sunspot, some filmy clouds begin to form a bridge across it, finally tumbling pell-mell into the cavity. Some of the liquid metals pour out over the sides like the petals of a giant sunflower, only brilliantly white in hue, while others resemble fringing ferns drooping over the edge of a pool. It is a beautiful sight, but we are suddenly compelled to make a hasty retreat as some mischievous imps within the whirlpool begin to bombard our tiny craft. We have much ado in escaping destruction, and had it not been for the strength of *Imagination* we certainly should have dropped in the centre of the fiery whirlpool. As it is, the Wings of Thought bear us safely away, though we nearly land on Venus by mistake. This is so much like planet

ELECTRONS STREAMING FROM THE SUN

VIEWS OF SUN FLAMES
Taken at Yerkes Observatory

Earth in size and appearance that they are called the twin planets.

Fortunately a keen-eyed passenger knew that our pilot must be mistaken, as Venus does not whirl round nearly



THE SUN'S CORONA
From "In Starry Realms," by Sir Robert Ball

as nimbly as her sister Earth. So we veer off in the right direction, landing on planet Earth just in time to witness another wonderful sight.

It is September 12th, 1923, when a total eclipse of the Sun is due, according to the calculations of the astronomers at Greenwich. They knew that the Moon was going to pass exactly in front of the Sun and cut off his light, so that for a few minutes a part of the Earth would be

almost as dark as at night. Now it may seem odd that the Moon, which is such a little body, and four hundred times smaller than the Sun, should be able to extinguish its light. But it comes four hundred times nearer. Sometimes it is exactly between the Sun and the Earth, and if at that time we are so fortunate as to be directly within the track of the shadow which it casts we are enabled to see the most wonderful sight imaginable.

The Sun is surrounded by the corona, a marvellous crown of pearly light, which is usually hidden by the glare of sunlight. Now when the Moon cuts off that glare by coming directly between us and the Sun, we have what is called a total eclipse of the Sun. This can only last for a few precious minutes. As the Moon hides more and more of the Sun's light, the sky gradually darkens, and birds can be heard twittering in their nests because they think that it is evening.

Just before the last crescent of sunlight vanishes the dark shadow cast by the Moon sweeps over the Earth like a mighty wave. Next instant out flashes the corona in all its splendour, encircling the Moon, which hangs like a dark globe in mid-air. Imagine the two outlined against the dark background of the sky, and you may gain some idea of the impression made in days of old upon the watchers of the sky as they witnessed the sudden disappearance of their Sun-god. No wonder they were filled with alarm!

Is it surprising that they imagined some conflict must be taking place between the Sun and a monster trying to devour it—the monster being the Moon? In China it was customary at such times to bang kettles and pans together, making all the noise possible so as to frighten the monster away.

Certain astronomers were entrusted with the important task of calculating when an eclipse was due, so that every one might be in readiness, including the pots and pans. In 2169 B.C., we are told, several astronomers lost

their lives because their calculations were not correct. On another occasion two astronomers name Hi and Ho were so busily engaged in playing a game of chess that they forgot to give the necessary warning, and they lost their heads in consequence.

The Northmen tell us that eclipses are caused by two hungry grey wolves which are for ever pursuing the Sun and Moon. When the wolves succeed in swallowing either of them, and so cause an eclipse, the Earth-children make such a noise that the wolves drop their prey in fear.

Then there are stories explaining why the Sun always goes along the same path in the sky each day, instead of wandering about as he pleases. At one time, so say natives in the Pacific, Ra, the Sun, who in form resembles a man, went so rapidly across the sky that Maui, the greatest hero of the South Seas, decided to lay a trap for him and make him go more slowly. He plaited six great ropes of strong coconut fibre, each of four strands, and of a great length.

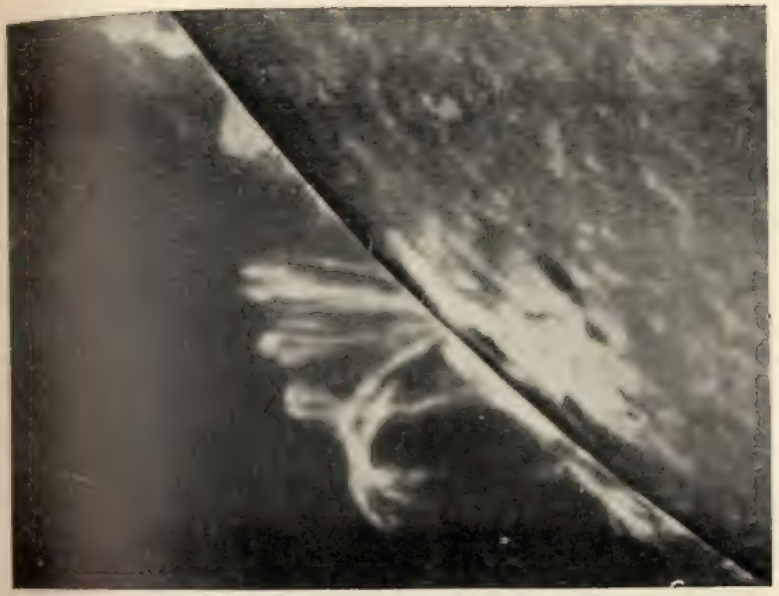
MAUI LAYS A NOOSE FOR THE SUN

He started off with his ropes in his canoe to the distant aperture through which the Sun climbs up from Avaiki,

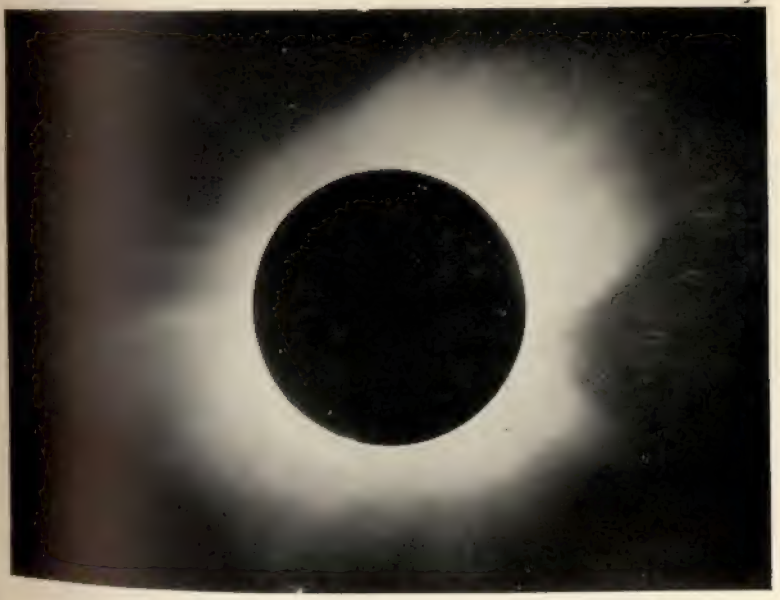
or the land of ghosts, into the heavens, and there laid a noose for him. Farther on in the Sun's path a second trap was laid, until six ropes had been placed at intervals along the path travelled by Ra. Very early in the morning the unsuspecting Sun clambered up from Avaiki to make his usual journey across the sky. Maui was waiting for him near the first noose, and he pulled it, but it slipped down the shining body and only caught Ra's feet. Maui ran forward to look after the second noose, but that also slipped, though it closed round the knees of the Sun. The third caught him round the hips, the fourth round the waist, the fifth under the arms. Still the Sun rushed onward, scarcely heeding the ropes, but finally the sixth and last caught him round the neck, and he was trapped.

Ra struggled to get free, but Maui fastened the rope to a point of rock, until the Sun promised to go more slowly and give people time to finish their work. Even an oven of food could not be prepared or cooked before the Sun had set, and the world was overtaken by darkness. Ra agreed to the demands of Maui, who allowed the Sun to proceed on his way, but declined to take off the ropes, wishing to keep Ra in constant fear. These ropes may be seen hanging from the Sun at dawn, and when the Sun descends into the ocean at night. By the assistance of the ropes he is gently let down into Avaiki, and in the morning raised up out of the shades. When the islanders see the long rays reaching from the Sun down to the sea, they say, " Behold, the ropes of Maui."

In concluding this story of the Sun a few facts of interest should be noted. First of all, its great size as compared with the Earth ; its diameter exceeds that of our planet 109 times. If a tunnel could be made through the Sun, there would be ample room in this for 109 globes as large as our planet. Could the Sun be weighed in a balance, it would take 332,000 globes the weight of the Earth to make the scales even. In volume it exceeds that of the Earth 1,300,000 times, so that if a million



SUNSPOTS AND SUN FLAMES
Taken at Yerkes Observatory
[See p. 22]

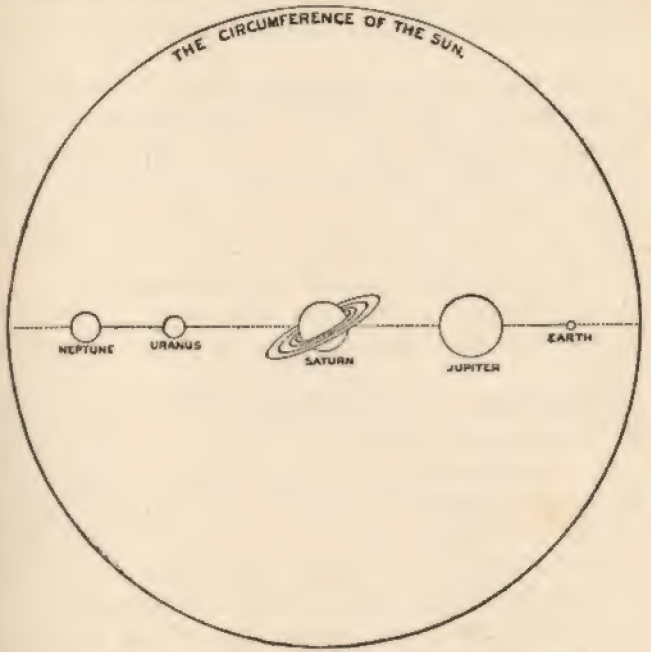


THE SUN'S CORONA
Taken by Dr Crommelin at Sobral, Brazil
[See p. 24]

THE EARTH AND MOON IN SPACE

From *Splendour of the Heavens*
By permission of Messrs Hutchinson and Co.
[*See p.* 37]

globes as large as our planet could be welded together the vast globe thus produced would not be as large as the Sun. A body weighing one pound on the Earth's surface would there weigh a little over 27 pounds; con-



COMPARATIVE SIZE OF THE SUN AND THE PLANETS

From "In Starry Realms," by Sir Robert Ball

sequently a boy weighing seven stone here would find great difficulty in walking about on a globe as huge as the Sun; should he be so unfortunate as to fall, he would require the assistance of a derrick to get him on his feet again. It is clear, therefore, that a game of football on the Sun would be an impossibility; the ball would weigh 27 times as much as it does here, and it would need an extremely vigorous kick to start it going.

Then with regard to the heat of the Sun, every boy

knows how a hole can be burnt in a leaf if a magnifying glass is held directly between the leaf and the Sun. It is said that during a siege of Syracuse in the year 214 B.C. the renowned philosopher Archimedes burned or scattered the Roman fleet under Marcellus by concentrating sun-rays upon the ships by means of mirrors erected on the shore.

A sun-machine was invented in 1882 by a Frenchman named Mouchez. It looked like an inverted umbrella pointing sunward, and was exhibited at the Paris Exposition of that year. It consisted of a great reflector, shaped something like an opened umbrella, which concentrated the Sun's rays on a boiler at its centre, and so drove a steam-engine, which was employed in turn to work a printing-press. In this way a daily paper was printed for distribution among the visitors to the Exposition.

To get some idea of the intense heat of the Sun, if all the coal in the world were piled into a huge furnace and set on fire the amount of heat produced would only be equal to that given out by the Sun in the tenth part of a second! If a bridge of ice could be formed by a block of ice 2½ miles square at the base, extending across the vast chasm of ninety-three million miles separating us from the Sun, and if by some means the whole of the Sun's heat could be concentrated on the block, it would be melted in one second, and dispersed in vapour in seven.

Finally, a few words with regard to the light showered on our planet by the beneficent Sun, who pours his rays upon us so generously. All light is borrowed from the Sun. Moonlight is reflected sunlight, and, to quote Tennyson, the moon is

> Dead, but how her living glory lights the hall, the dune, the grass!
> Yet the moonlight is the sunlight, and the sun himself will pass.

It is the sunlight dancing on the waves which makes them sparkle with tints of blue and green. The rainbow

hues at sunset are all painted by the Sun, as well as the red of the rose and the purple of the violet. Go into the garden some evening when daylight is fading, and you will find that these gaily coloured flowers have vanished in the dusk. Then look around at the white flowers; you will see them standing out plainly visible till the last ray of twilight has departed. That is because the lily gives back all the light that falls upon it, while the rose and the violet give back only a small part and suppress the rest.

In his "Hymn of Apollo" Shelley tells us about some of the work accomplished by the Sun-god:

> I feed the clouds, the rainbows and the flowers
> With their æthereal colours; the moon's globe
> And the pure stars in their eternal bowers
> Are cinctured with my power as with a robe;
> Whatever lamps on Earth or Heaven may shine
> Are portions of one power, which is mine.

The astronomer has invented symbols for various of the heavenly bodies, and as these are often used in almanacs and books it is as well that we should be able to read them. They remind us of the picture-writing of the ancients in the long-ago before our alphabet was thought of. The Sun is represented by ☉, and the Moon by ☾. The symbols of the planets are as follows: ☿ Mercury; ♀ Venus; ⊕ the Earth; ♂ Mars; ♃ Jupiter; ♄ Saturn; ♅ Uranus; ♆ Neptune.

CHAPTER II

THE STORY OF THE MOON

How like a queen comes forth the lonely Moon
From the slow opening curtains of the clouds;
Walking in beauty to her midnight throne!

GEORGE CROWLY

ONCE upon a time the Moon was a part of the Earth. That was long ago, probably about fifty million years or so, when our planet was a soft molten mass, with oceans of liquid metal, from which ascended clouds of steam. It was whirling round at a terrific rate, so that the day lasted for only two or three hours, instead of twenty-four as it does now. It could not have whirled much faster without flying to pieces.

The Earth was soft as putty in those days, and as it spun round it began to bulge at the equator, until finally a huge fragment was thrown off which eventually became the Moon. Some say that it came out of a deep, fathomless hole in the Pacific, but as no one was around at the time it was flung off from our planet this cannot be proved. Yet we know there is a very deep hole there, and the Moon, which is only a little over two thousand miles in diameter, would have fitted in very nicely, with plenty of room to spare.

The huge fragment, which was as soft as the Earth was then, began whirling around until all the rough, chunky edges were rounded off, and it gradually assumed the shape of a globe such as we see in the sky on moonlight nights. At first the baby Moon was so near Mother Earth that they were almost touching, and for a long time they were facing each other. We can imagine the

Moon watching for a chance to escape while Mother Earth was looking the other way.

As the truant grew older, it became more and more independent, gradually getting farther and farther away, until it is now nearly two hundred and forty thousand miles distant from its parent orb. In fact, it would

THE SIZE OF THE MOON IN PROPORTION TO EUROPE

seem to be making a desperate effort to fly off into space altogether, but Mother Earth holds it back with the invisible bond of gravity, the weight or pulling power which attracts everything, including ourselves, to the centre of the Earth.

With this same force the Moon and the Sun are pulling at the Earth, but as the Sun is four hundred times as far away as the Moon the strain is weaker. Now this daily tug-of-war between the Sun, Moon, and Earth is the cause of the tides. At the time of New or of Full

Moon the Sun and the Moon are pulling together. Then the tides are high, but at Half Moon, when the Sun is pulling at the water on one part of the Earth, and the Moon at another, or crosswise, the tides are low. When we go to the seaside during the summer-time it is very important to know which is the best hour for bathing, and when the tide will be high or low.

There is usually a board placed where every one can see it on the beach, and it has the hours of low or high tide written on it very distinctly. Sometimes you will see a red flag, which means "No bathing to-day"; this is usually because the waves are too rough and would knock people down should they enter the water. Or else maybe there is an undertow which seems to hold your feet fast, while the top of the wave tumbles you over.

However, whether it is rough or smooth, you will find that the time of high and low tide varies from day to day, so that it will usually be an hour or so later to-morrow than it is to-day. This is all carefully recorded in the almanacs, and we get our facts from the *Nautical Almanac*. The English edition is published at the Greenwich Observatory. This may seem odd, since the famous observatory is situated in the middle of a beautiful park miles away from the sea. Some people have an idea that an astronomer goes down to Brighton, let us say, on Monday, and sits on the beach watching the waves as they come rippling to and fro, until they come in so fast at high tide that he has to beat a hasty retreat, like Canute of old. Then when he is well out of range of the splashing waves, he takes out his pencil and makes a note in his book to the effect that it was high tide—let us say—at ten o'clock. Then on Tuesday it will be high tide at eleven o'clock, and so on for the rest of the week, and the record is complete.

As a matter of fact, the calculations are made far away in the quiet of the Greenwich Observatory, and they

depend upon the position of the Sun and the Moon with regard to each other. Moreover, these calculations are made two or three years in advance, so that if you wish to know when it will be high or low tide at Brighton on the South Coast of England any day two years hence, you can find out at once by consulting the *Nautical Almanac* for that date. Not a ship goes in or out of a port without consulting the English or the American *Nautical Almanac* about the tides. It was to assist navigation that the Greenwich Observatory was founded.

The boatman who takes us for a sail on the water in the afternoon knows full well that at certain times the tides rise higher and fall lower than at other times. He knows, too, that it is useless looking for passengers when the tide is so low that nothing but a stretch of sand or shingle can be seen for ever so far. Then you will see his boat high and dry on the beach, and the owner mending his fishing-net, or doing something else that may be useful or necessary. But he has one eye on the sea, and as the waves come creeping nearer and nearer you will see that he is on the alert. High tide comes at last, and then the water begins to recede.

That is the signal he has been waiting for. Dragging his boat down from the beach, he gets everything in readiness so that it may be launched into the 'vasty deep,' and presently you may hear him calling, "All aboard for the *Skylark*," or whatever the name of his boat may be, and he is ready to take us out on the falling tide. Presently, after a more or less delightful trip, depending upon whether the sea is rough or smooth, we are brought back on the rising tide, which seems anxious to hurry us to the beach.

The tides not only help us to enjoy an outing in this way, but they can also be made to do very useful work such as removing sand and mud when they block up a narrow channel. Backward and forward the water rushes, until the sandbank gradually disappears and large

vessels can pass through with ease. The tides also build up, as at Fundy Bay, in New Brunswick. The entrance to the Bay is shaped like a funnel, and through the wider opening of the funnel the waters of the Atlantic rush at high tide in a mighty volume of water which piles up forty or fifty feet by the time it has reached the narrow end. The dreary mud-flats which are seen at low tide are now turned into a wide estuary, leaving behind it deposits of red mud which rise higher and higher until they can be dyked.

Just before old London Bridge was destroyed, water-wheels, which had remained in use until 1822, came to the end of their days of usefulness. Their story is of interest, as about a hundred years ago London's supply of water was chiefly obtained by means of tidal mills at London Bridge. In olden times water was a luxury in London, and from City records of 1236 we learn that the water-carriers had to go to the Thames for supplies until great conduits or channels were constructed.

In 1571 a big scheme to bring the waters of the river Lee into the City conduits was set on foot, but this was not enough. In 1781 Peter Morrys, an enterprising Dutch engineer, formed the plan of using the force of the tide running through the arches of London Bridge to pump Thames water into the City. Old London Bridge had many more arches than the present one has, and, the channels between them being quite narrow, the water rushed through with great force. 'Shooting the Bridge' on a raft was considered a daring feat. Morrys and his pumps were at first very useful in thus harnessing the rushing waters. In the basement of the London Museum there is a model of old London Bridge, showing the position of some of the conduits through which water was pumped into the London area in those days.

Thus we see how the tides do useful work, scouring out river channels and moving sand-banks, though they are no longer pumping Thames water into the City of

London. But the Moon must not get all the credit; though it causes the tides, it is the Earth which provides the energy.

The Earth turning round and round upon its axis is like the fly-wheel of an engine, only as it happens it is without an engine. When the tides have withdrawn all their energy the Earth will run down like a clock that is not wound up. The day will get longer, as the Earth turns more and more slowly, and millions of years hence the day and the month will again be equal, but it will be a day lasting fourteen hundred hours! Mr Wells, in his story of *The Time Machine*, has drawn a wonderful picture of the Earth in those far-off days. He imagines the Earth as having reached the stage when it turns one face to the Sun. The huge red-hot dome of the Sun has come to obscure nearly one-tenth of the heavens. But it gives out very little heat. It is very near the Earth, for a resisting medium has drawn the latter inward.

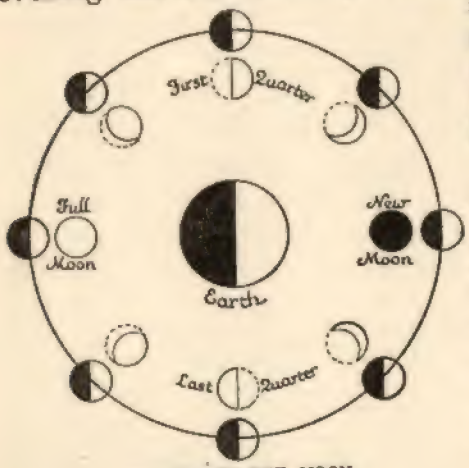
Some fine evening while enjoying a walk in the country where it is possible to obtain a clear view of the sky, you raise your eyes and suddenly perceive a slender silvery crescent in the west. This is the New Moon, shining with reflected light from the Sun, which has just disappeared below the western horizon. She seems to be travelling rapidly from east to west, but this is not so, as her movement is in exactly the opposite direction, from west to east. The truth is that the huge Earth whirling past as it twirls on its axis from west to east overtakes her in the heavens.

The Moon has just shown her pale face over the western horizon, from which she is hurrying at the rate of 2,300 miles an hour, but all in vain, for the Earth, ponderous as it is, is too quick for her; it is travelling nearly thirty times as fast. In a little while the Moon disappears like a snowflake in the west, and we see her no more that night.

But watch again for her the next night, and you will

find that she is still in the western sky, but a little farther from the west than before. She is somewhat larger and brighter and her horns are turned toward the east. Probably the background of the sky against which she shines is a little darker, so that a few stars are visible, and these will be her escort. Meanwhile the Earth sweeps on as before, and once more the Moon disappears with the stars following in her train, but a little later than the evening before. She has only gained a little on her pursuer, which rolls by, every point on its surface whirling rapidly past her as she vanishes in the west.

The next night we find that the fickle Moon has deserted the stars which accompanied her last evening, and has found new followers farther eastward. With them she is hurrying rapidly on her way, to be again overtaken by the pursuing Earth. But at last at the end of two weeks she seems to have gained the victory, for that evening she has actually reached the eastern horizon, and she rises in beauty as the Full Moon in the east, setting in glory in the west a few hours later.



PHASES OF THE MOON

Thus each night she rises later and later, until at length we see her no more, except at sunrise in the morning as a slender crescent, and now even this fades in the glory of sunlight. A day or so later on raising our eyes to the heavens, there, in the west, the same pale, silvery crescent meets our gaze in precisely the same position as we saw her at first. And

what does she say to us? "Since last you saw me here a month has rolled away."

But while all this has been taking place, there have been changes in the appearance of our satellite, as the Moon is called. These changes tell us the Moon's age for the month; they are usually called phases or quarters. When she has completed her First Quarter, as it is termed, she has passed from the crescent phase and presents herself as a Half Moon.

The next stage of her journey brings her into opposition, as it is called, on the opposite side of the heavens, when she presents her full face to us and is at her best. From that point, having now arrived to the westward of the Sun, the phases are reversed and her horns are turned toward the east. It would be well to look for these changes when the Moon is to be seen; even artists sometimes show that they do not use seeing eyes, for I have seen pictures in which a crescent Moon is painted with its horns pointing in the wrong direction.

Having reached her Last Quarter our satellite is again a Half Moon, finally dwindling to a thin crescent, seen at sunrise, disappearing altogether for about three days, when she is in conjunction, that is, in a line with the Sun and Earth.

Near the time of New Moon the portion of the Moon's surface which does not get the sunlight is easily visible, being illuminated by a pale reddish light. This light is earthshine, the Earth as seen from the Moon being then nearly full. This earthshine is probably fifteen to twenty times as strong as the light of the Moon at the time of Full Moon.

Since the Moon always keeps the same face turned toward the Earth, the latter is visible only from that part of the Moon which faces us, and it remains nearly stationary in the lunar sky, neither rising nor setting. It is easy to see that our planet would be a very beautiful object, reflecting the sunlight as does the Moon, and

surrounded by ever-changing masses of clouds, through openings in which peeps could be seen of her variously tinted surface, blue oceans, green trees, and orange-tinted desert regions.

A story is told of a learned professor who on one occasion was on his way to a hall in which he had been invited to give a lecture on the Moon. He was accompanied by the chairman who was to introduce him later on to the audience. Wishing to glean a little knowledge on the way from the hotel to the hall, the chairman remarked thoughtfully, " We are all looking forward with the greatest pleasure to the lecture you are giving this evening. I know I am, and I am specially anxious to learn why we sometimes see the Moon as a crescent and sometimes full," adding with a sigh, " but I expect that is one of the problems which will never be solved."

As a matter of fact, it is no problem at all, and a very simple experiment will show why the Moon presents phases. Place a lamp in the centre of a table, after extinguishing any other light in the room. Let us suppose that the lighted lamp is the Sun ; a white ball—a billiard ball is specially good for the purpose—will represent the Moon, and your head will answer for the Earth. Now stand in front of the lamp, holding out the ball at arm's length between your head and the lamp. This represents the Sun, Moon and Earth in line, at the time of what is termed conjunction.

Now turn slowly round to the left, and you will see a silver crescent on the ball gradually growing to the Half Moon or First Quarter. The ball must be lifted a little so that the light of the lamp shines over the top of your head, producing the phase of Full Moon. You have only turned half-way round, so continue turning, and you will find that the phases are reversed—the gibbous, the Half Moon representing the Last Quarter, then a slender crescent, and finally the New Moon phase.

This illustration also shows how a total eclipse of the

Sun can only occur at the time of New Moon, when the Moon comes exactly between the Sun and the Earth, and is near enough for its shadow to reach our planet. A total eclipse of the Moon, on the contrary, can only occur at the time of Full Moon, when the Earth is directly between the Sun and the Moon, and thus hides the light of the Sun. As a rule the Moon at such times is illuminated with a dull copper-coloured light from the rays of sunlight reflected in the atmosphere of the Earth. In the lunar eclipse of 1884 the Moon became for a time absolutely invisible, a very unusual event.

You doubtless know the story of Christopher Columbus, who made use of his knowledge of astronomy on one of his expeditions when he found himself and his companions reduced to starvation. The natives were very unfriendly, and the outlook was gloomy until Columbus recalled the fact that a total eclipse of the Moon was due on a certain night.

When his request for food for himself and his companions was again ignored he threatened the natives that he would put out the light of the Moon unless provisions were brought at once. The natives cared little for his threats until they saw the light of the Moon gradually disappearing. Then they ran to Columbus with stores of food and implored his pardon, hailing him as a great chief or conqueror. This eclipse of the Moon actually occurred on March 1st, 1504, a date which may be tested by our records of the Moon.

Ancient history tells us of an eclipse which was the cause of the defeat of the Athenian army and the death of Nicias, their general. He was just about to depart from the harbour of Syracuse when an eclipse of the Moon filled him and the whole army with dismay. As a result of his terror, he delayed the departure of his fleet, with the consequences mentioned.

There is another point that seems puzzling, though it can be easily explained. How is it that, as we have

stated, the Moon always keeps the same face turned to the Earth? Here we remove the lamp from the centre of the table and put the ball which is to represent the Earth in its place. This time your head will represent the Moon as you walk round the table, always keeping your eyes on the ball.

These illustrations are so simple that even the smallest children can try them and understand them for themselves.

I remember an experience I had in Wellington, New Zealand, in connexion with a little boy who was then five years old. His father was very interested in astronomy, and apparently the little boy had heard him talk about eclipses and how they are caused.

One evening his parents had gone to an entertainment of some kind, leaving me in charge of the deserted house, the boy having been sent to bed. Presently he came pattering down the stairs, and not having the heart to send him back again, I settled him comfortably on a sofa, and covered him with a rug. Resuming my writing, presently I heard a small voice remarking, "Total 'clip, total 'clip." For a moment or so I imagined that the child was talking in his sleep, until I realized, when I at length turned round to see what was the matter, and the child joyfully exclaimed, "'Clip over," that my head had been between the light from the lamp and the small boy's face, thus causing a total eclipse.

Although the Full Moon shines so brightly that in some places, especially the tropics, it is possible to read by its light, yet the light of six thousand Full Moons packed together in the sky would be required to equal the light from the Sun. The Half Moon does not give nearly half as much light as the Full Moon. Near the Full the brightness is suddenly and greatly increased, probably because at any time except the Full the Moon's visible surface is more or less darkened by shadows which disappear at the moment of Full. There are, however, great differences in the brightness of different parts of the

Moon's surface, some parts appearing white as snow, and others dark as slate.

If you have an opportunity for seeing the Moon through a telescope, however small, do not miss it. Through the kindness of the late Professor E. E. Barnard, I once was permitted to observe a part of its surface through the great 40-inch lens at the Yerkes Observatory. It was fascinating to look down upon that sea of shimmering silver, and to peer into the dark abysses known as craters. The observer feels suspended above their cavernous depths, and the fear that he may lose his hold upon this planet and fall into those unknown depths is overwhelming.

In the days of old the Moon was supposed to be covered with a sheet of glass which reflected the continents and islands on our planet; these, of course, were the dark markings on the Moon. One can imagine, therefore, the surprise with which Galileo in 1609 gazed for the first time through what was called a 'magic glass' at the surface of the Moon, discovering that it was a world like ours, with mountains, hills, and valleys, and, as he thought, seas and plains, which he named accordingly. Hence, in a map of the Moon, we see such names as 'the Sea of Serenity,' 'the Sea of Tranquillity,' 'the Bay of Rainbows,' and 'the Lake of Dreams.' By these fanciful names the regions are still known, although in reality there is not a drop of water on the Moon. Nor is there a sign of vegetation anywhere, not a tree, a flower, or even a blade of grass to relieve the dreariness of the scene.

But before we start on our ramble over the Moon it is interesting to learn how the use of 'magic glasses' was first discovered in 1608 through the curiosity of a boy, the son of Jean Lippershey, an optician of Middelburg, in Holland. One day the boy was playing with some spectacle lenses he had found in the shop. He happened to put one in front of another, and looking through the two glasses at the clock in the Cathedral tower, to his

great surprise it appeared much nearer, and the figures on the face were upside down. According to some stories it was the weathercock on the church spire which was seen nearer and upside down. At any rate, the discovery was made, and, according to the story, the father, after

LIPPERSHEY DISCOVERING THE LENS

looking through first one glass and then the other and finding that only by placing one in front of the other were distant objects seen to be near, adopted the ingenious idea of fixing them in draw tubes as in modern telescopes, selling them as ' magic glasses.'

The story goes on to relate that the Marquis Spinola, happening to call at the shop, was so pleased with the toy that he bought it for his own entertainment. He showed it to Prince Maurice of Nassau, who thought it might prove useful in war-time, as it would reveal approaching ships long before they could be seen with

GALILEO EXHIBITING HIS INVENTION OF THE TELESCOPE
Evelyn Paul

the naked eye. Jean—though he is sometimes referred to as Hans—Lippershey, realizing that the ' magic glass ' was of value, made a petition on the 2nd of October, 1608, to the States-General of Holland for a patent. The aldermen, however, saw no advantage in it, as an observer could only look through it with one eye at a time. They refused to grant the patent, and although the discovery was soon found to be of the greatest value poor Lippershey reaped no benefit.

Soon tidings of the discovery found its way to Padua, and Galileo was among the first to hear of the ' magic glass.' All night long he pondered over the news, wondering if he could not improve upon the strange instrument, so that the Sun, Moon, and planets might be brought close to the eye. He knew about lenses and magnifying glasses, and he had read a book on optics, that is, the science that treats of light and vision, by Kepler; moreover he had himself given lectures on the subject.

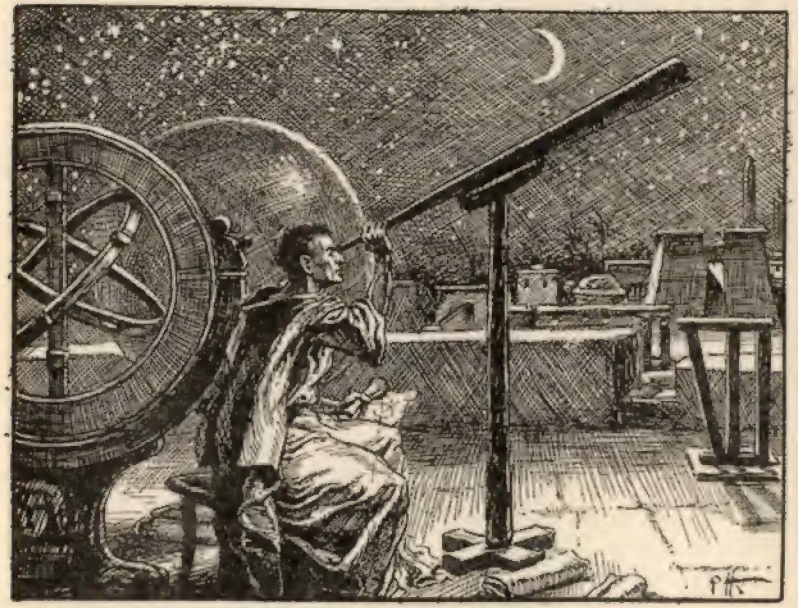
After many hours of deep thought he took a small pipe out of an old organ and fixed a convex glass in one end and a concave glass in the other. This rough instrument was capable of magnifying three times and it resembled the half of an opera-glass. It was better than the Dutchman's ' magic glass,' because it did not invert. Such a toy as Galileo made may now be bought for a few shillings, and yet this was the ' optic glass,' as Milton called it, through which Galileo first observed the Moon, enabling him

> to descry new lands,
> Rivers, or mountains, in her spotty globe.

Galileo went with it to Venice, and showed it to the nobility, to their great astonishment.

> " Many noblemen and senators," he wrote, " though of advanced age, mounted to the top of one of the highest towers to watch the ships which were visible through my glass two hours before they were seen entering the harbour, for it makes a thing fifty miles off as near and clear as if it were only five."

Among the people, too, the instrument excited the greatest astonishment and interest, so that he was nearly mobbed. The old senators in their interest in the newly revealed worlds were constantly climbing the steps leading to the tower, till Galileo " became annoyed



HIPPARCHUS AND HIS INSTRUMENTS

at their importunity." He scarcely had a chance to observe the surface of the Moon himself, and he was keenly anxious to discover whether it was habitable. But it was left for the giant telescopes of later days to prove conclusively that it is not.

Fourteen hundred years before this, Hipparchus, the greatest astronomer of antiquity, had made use of a tube in his observation of the heavens. As this had no lenses it did not, of course, bring the stars nearer to his vision. It was helpful, however, in shutting out the diffused light of the Sun, and Hipparchus was thus enabled to make

observations at all hours, just as we may see the stars from the bottom of a deep pit-shaft in the middle of the day. Hipparchus made the first catalogue of the stars, and the size, brilliancy, and movements of about one thousand out of the three thousand stars visible to the naked eye were noted. This catalogue served as a basis for the astronomy of the Middle Ages, and we may marvel at what this old astronomer accomplished with his primitive instruments.

It is true that in various lands legends have been told and fables invented about the supposed inhabitants of the Moon, including the famous 'Lunar Hoax' (see pages 58–60), but no trace of possible inhabitants has been discovered.

But we will leave fable for the moment and consider these facts regarding the Moon : Its distance from us is 238,840 miles, or about thirty times the diameter of the Earth. That is, if thirty globes the size of the Earth could be placed one on top of the other, they would reach from the Earth to the Moon. If a suspension bridge could be built across the intervening space, and we walked continuously at the rate of four miles an hour, it would take us seven years to cross it. If we went on horseback with a good horse which trotted three hundred miles a day, we should reach the Moon within three years. A train going at the rate of a mile a minute would land us on the Moon within six months, but should we adopt the plan of being propelled to the Moon in a huge cannon-ball travelling at the rate of 1,312 feet per second, the distance between the Earth and the Moon would be covered in eleven days.

An even more speedy transport has been seriously suggested by Professor R. H. Goddard in America. His early experiments have not been successful, but failure has not discouraged him, and he has obtained the support and approval of the Smithsonian Institute and the American Association for the Advancement of Science.

His idea is to use a steel rocket so made that a series of powerful explosions will take effect at successive points upon the flight. As the effect of one is spent then the next charge explodes, until at an immense height a second rocket contained within the first will be discharged. This will pierce clear through the atmosphere of the Earth and it will, Professor Goddard believes, continue until it falls upon the surface of the Moon, thirty-six hours after its release from Earth. Contact with the Moon will ignite a powder which will flare up, and observers on Earth will be able to see the flash with the aid of telescopes of twelve inch and larger. To assist in this the experiment will be made when the Moon is in a crescent phase in the hope that the flash may occur against the dark shadow-background. The late Sir James Dewar, a great scientist, thought that sooner or later Professor Goddard's experiment would succeed.

In his book entitled *From the Earth to the Moon* Jules Verne describes the experiences of three adventurers who set out to visit the Moon. By special arrangement with a Gun Club to which they belonged they were fired from a cannon by means of such a powerful explosive that the projectile in which they were encased should have reached the Moon. However, through a slight error made in their calculations they did not get within forty miles of its surface. Although this was a splendid opportunity for getting a close view of our satellite, the adventurers were faced with the dreary prospect of wandering aimlessly in space and possibly with a risk of crashing into something as they drifted. Fortunately, by means of an ingenious device these dangers were averted, and the voyagers were enabled to return to the Earth in safety.

Abbé Moreux, another ingenious French writer, in his book called *A Day on the Moon*, states that a shell fired from a cannon with an explosive powerful enough to propel it seven and a half miles a second at the beginning

THE MOON
Photographed at Lick Observatory

SELENE AND ENDYMION
G. F. Watts
By permission of Mr Frederick Hollyer

of its flight would never come back to Earth. Moreover, he suggests that such shells might be used to convey letters to the inhabitants of the Moon.

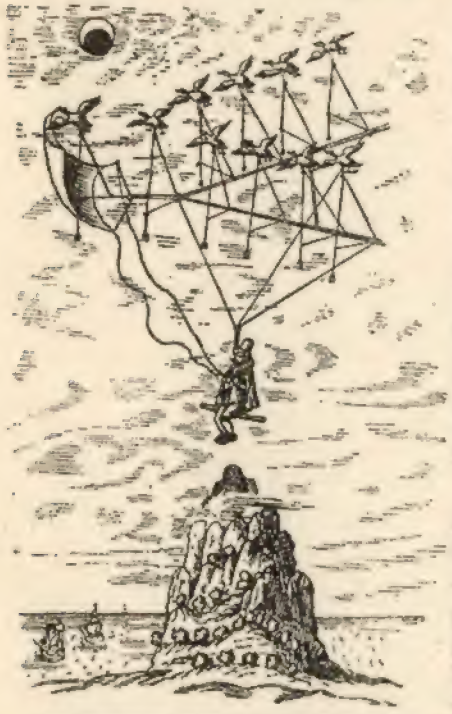
A message dropped in the letter-box of the London-Moon Post Office at six o'clock in the morning should reach the Man in the Moon at three o'clock that same afternoon. The slightest delay would prove extremely awkward, as the Moon is always on the move, and the shot containing the letter, finding no billet to receive it, would go on and on to some unknown destination. Inquiries at the London-Moon Post Office would probably bring the reply, " No trace."

Various accounts have been written of imaginary attempts to reach the Moon by means of flying-machines. A description of such an attempt is told in a Greek story, two thousand years old, concerning Icarus, who made a flying-machine out of the right wing of an eagle and the left wing of a vulture. Fastening these to his shoulders with straps, he placed his hands through loops at the end of the quill feathers. Thus equipped he journeyed to the Moon, which he found to be " a great round and shining island which hung in the air, and was inhabited. The inhabitants were Hippo-gypians, and their king was Endymion."

Of course, you know the story of Endymion. He was cast into a profound slumber on the Latmian Hill by the goddess Selene (Diana) because he refused her love, but at sunset she used to visit him, and we can imagine the tender looks she cast upon him while he slept. There is a meaning hid within this simple story; it is that the rising Moon looks down on the setting Sun. The story tells also why the inhabitants of the Moon are sometimes called ' Selenites.'

> Then, as the full orb poised above the peak,
> There came a lovely vision of a maid,
> Who seemed to step as from a golden car
> Out of the low-hung moon.

In the year 1638 Dr Francis Godwin, of Hereford, wrote a book which contains an account of an aeronaut who was carried up to the Moon by ten wild swans. This may seem to have been a dangerous adventure, but it was surpassed by Cyrano de Bergerac, who attempted to reach the Moon without external assistance of any kind. He simply went, and an old engraving shows him in the act of cheerfully skipping upward. The artist made the mistake, however, of drawing the Moon full though it is near the Sun!



DR GODWIN'S JOURNEY TO THE MOON

Although we cannot reach the Moon in any such ways, yet by means of a telescope, a field-glass, or even an ordinary spy-glass, which can be bought for a few shillings, we can see far more detail on the Moon's surface than with the naked eye. It seems very much like peering into a neighbour world's window, as Mr Garrett P. Serviss, a well-known writer on popular astronomy, expresses it, but surely the Man in the Moon will excuse our curiosity concerning the world of wonder in which he is said to dwell.

First of all we must have a good guide, and Sir Robert Ball's *Guide to the Heavens* will come in handy. It has a plan, with an accompanying key, of the markings on the Moon from the time it is a crescent until it is full, which

can be easily followed. Study the plan for a few minutes during the day, and then look for the places marked in the evening. It is possible to learn more of the appearance of the Moon in this way than by simply reading books about it.

With the aid of a magic glass of some kind the shadows of the mountain peaks can be traced as they advance at sunrise across the lunar plains, and recede at sunset a few evenings later. A circlet of what seems like glistening gems on one night proves on the next to be the rim of a crater partly illumined with sunlight. Bright detached dots beyond the crescent denote the summit of a mountain peak just catching a ray of sunlight.

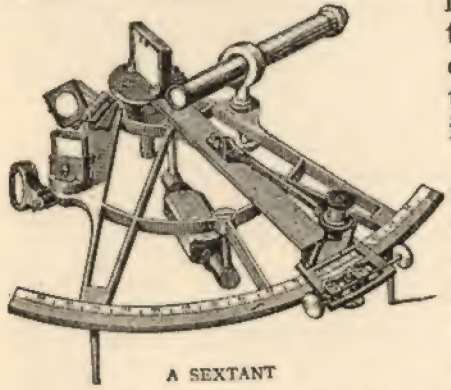
DE BERGERAC ATTEMPTS TO REACH THE MOON

With another book by Mr G. P. Serviss, *Astronomy with an Opera-glass*, to accompany the *Guide* it is possible to read in advance something about each region of the Moon which we desire to observe. First of all there are the greyish-looking plains which, as I have said, astronomers of old called 'the Bay of Rainbows,' 'the Lake of Dreams,' 'the Sea of Serenity,' and so forth. We see, in imagination, the inhabitants of the Moon drifting about in silver galleons and glistening barges, though on looking through our magic glass at the Full Moon we find that its silvery radiance is but a veil of reflected sunlight which conceals a scene of desolation.

The so-called seas are empty plains, which may have been filled with water once upon a time; now they are

dry and the water has long since evaporated. There are no clouds to lessen the effect of the intense heat on the Moon during a day which lasts as long as two weeks on our planet. Therefore, during this period the Sun's heat is so intense upon the surface of the Moon that the visitor would be broiled. The conditions are reversed during the fourteen days of lunar night, as, owing to the absence of clouds to retain the heat of the lunar day, the temperature must fall appallingly low, perhaps 200° or 300° below zero. Even the temperature of the regions on the Moon which correspond to our equator would be below the freezing point of water. The very thought of such trying conditions is apt to make one shudder, but Mr H. G. Wells, in his entertaining book, *The First Men in the Moon*, overcomes this difficulty by describing the inhabitants of the Moon as large insects living underground. As there are some thirty thousand lunar craters, and numberless craterlets, there is ample room and to spare.

However, another difficulty presents itself in the lack of air which is so essential to man, but Mr Wells brushes aside this objection with the suggestion that there may be air still remaining *inside* the Moon, where he has put his inhabitants. They certainly could not breathe on the outer surface of the Moon, where the air is frozen.



A SEXTANT

The fact that there is no air in the Moon can be proved by a pretty little observation we can make for ourselves, and without the assistance of a magic glass. There are nine bright stars lying along the Moon's path, which are sometimes referred to as nautical stars, because they are very useful in enabling

seamen to know where they are when out of sight of land. These stars are named Arietis, Aldebaran, Pollux, Regulus, Spica, Antares, Altair, Fomalhaut, and Markab. By means of a portable instrument called a sextant (not 'sexton,' as a boy once stated in an examination paper), a seaman, by measuring the distance of the Moon from any one of these stars, can tell where he is on the boundless ocean. As the Moon journeys across the sky, sometimes one of the stars passes behind the Moon and out again, and its disappearance and reappearance is as sudden as though its light had been extinguished like the flame of a candle. A child whose attention had been called to this was overheard to remark as the star disappeared, "Did the Man in the Moon blow it out?" It looked very much like it, and the child was immensely relieved when the star reappeared shining as brightly as ever. If the Moon had an atmosphere surrounding it like the blanket of air which surrounds our planet, the disappearance of the star would be gradual, just as we see stars fade at dawn, or brighten up at twilight.

The lack of air on the Moon would have another peculiar effect. As air waves are required to carry sound, should we be so unfortunate as to lose our way on the Moon during the course of a ramble amid steep cliffs and jagged precipices, where a mis-step would be fatal, we might shout with all the power of our voices, but none could hear us.

Moreover, the lack of atmosphere must cause startling effects in a lunar landscape. Distant mountains would appear sharply outlined against the sky, unsoftened be the misty haze which adds to the beauty of such a sceny on Earth. The stars would be always visible in a perfectly cloudless sky, which is always black as at night. They would shine with steady radiance, as there are no air waves to give them the effect of twinkling. As for the blue of our daytime sky, and the magnificent colours adorning it at sunrise and sunset, these are absent in the

lunar sky. The abrupt change from day to night would have the startling effect of suddenly hiding everything in a mantle of thick darkness. In the same way, by stepping from where it is light to where it is dark, as, for instance, within the shadow of one of the huge craters, we would vanish as completely as the Fairy Prince when he donned the cap which made him invisible.

Games and sport of any kind would be considerably altered on account of the conditions prevailing on the Moon, due to what is termed gravity. Sir David Gill used to tell the story of a boy at school who in answer to the question, " What do you know about gravity ? " replied :

" Gravity is, if you go to the top of a hill and jump up, you will come down again. If it were not for gravity you would never come down again. We ought to be very thankful that there is gravity."

Though oddly expressed, he had grasped the truth that it is gravity which holds us down on our planet, and the greater the mass under our feet the stronger the pull. Thus, we have already seen what heavyweights we should be on a globe as massive as the Sun, where the pull exceeds that of the Earth some twenty-seven times ; but it would be the other way about on the Moon. There the pull is only one-sixth ; our bodies would feel so light that it would almost be possible to run and jump as if we had on the famous seven-league boots. A labourer who can carry with difficulty a heavy sack on his back could tackle six such sacks with ease on the Moon.

Sir Robert Ball explains in his book *Starland* :

> What the labourer feels is not what he thinks he feels. He imagines that it is the weight of the corn, and the corn alone, which produces the pressure on his shoulders which he knows so well. No doubt he is right in a sense, but that is not exactly the way in which the philosopher will look at the same question. What the labourer does actually feel is the attraction between

> the Earth beneath his feet and the corn on his back. It is this force which produces the pressure on his shoulders. Its magnitude no doubt depends upon the quantity of corn in the sack, but it also depends on the quantity of matter in the Earth beneath his feet. In fact, the force between two attracting bodies depends upon the masses or weights of both the attracting bodies. When the labourer is transferred to the Moon, of which the mass is so much less than that of the Earth, the attraction is less there than it is here, even though the amount of corn is the same in the two cases.

Elsewhere Sir Robert Ball tells us how entirely most of our familiar games would be transformed in the Moon.

> In cricket, for instance, I don't think the bowling would be so much affected, but the hits on the Moon would be truly terrific. I believe an exceptionally good throw of the cricket-ball here is about a hundred yards, but the same man using the same ball and giving the same run to it, would send the ball six hundred yards on the Moon. So, too, every hit would in the lunar game carry the ball to six times the distance it does here. Football would show a striking development in lunar play ; a good kick would not only send the ball over the cross-bar, but it would go soaring over the houses, and perhaps drop in the next parish.
>
> A run with a pack of lunar foxhounds would indeed be a marvellous spectacle. There need be no looking round by timid horsemen to find open roads or easy gaps. The five-barred gate itself would be utterly despised by a huntsman who could easily clear a hay-rick. Nor would the farmer be astonished if all the field jumped over his house without disturbing a slate on the roof. It would hardly be worth while taking a serious jump to clear a canal unless there was a road and a railway or so, which could be disposed of at the same time.

The following, taken from Professor Newcomb's little book, *Astronomy*, gives some idea of how baseball would be affected on the Moon :

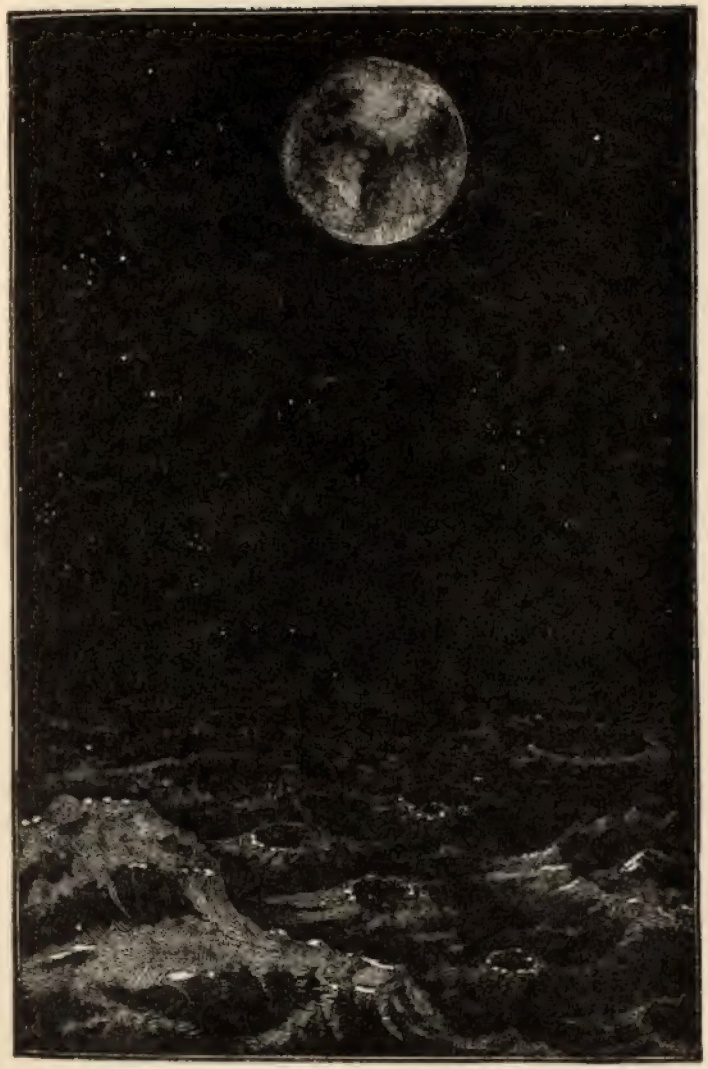
> If a baseball team could fly to the Moon and there play a game, the distinction between mass and weight would be very evident. The mass of the ball being the same as here, the pitcher would not be able to throw the ball any faster than he can throw it on the Earth. The catcher would find the ball striking as heavy a blow in his hands as it does here. As the ball would be drawn

towards the Moon by only one-sixth the force that the Earth draws it, it would be found to be as light as a rubber ball. It would stay long in the air when batted, and home runs would be made all the time.

A circus on the Moon would be a great event as compared with such an entertainment on our planet. Elephants would gambol as playfully as kittens. Acrobats would consider a jump over a cross-bar ten feet high mere child's play, taking a double somersault over an erection thirty feet high with the greatest ease.

It is considered a great feat for an athlete to jump over ten horses placed side by side, but it is a mere trifle as compared with the sixty over which he could vault if he were on the Moon. A strong man who can lift great weights and show amazing powers of endurance would be able to lift weights six times as heavy; he would think nothing of balancing a pyramid of thirty people on his head were he invited to take part in an entertainment on the Moon.

Again leaving the realms of imagination for fact, let us turn our magic glass in the direction of the most famous, though not the largest, of the crater mountains. It was named Tycho, by Galileo, after the great astronomer Tycho Brahé. It is about fifty-four miles across and three miles deep. In the centre there is a peak five or six thousand feet high, a good stiff climb over rough and irregular ground. A dark rampart, twenty-five miles broad, surrounds the crater, and bright streaks can be seen reaching out from it in all directions, giving it the appearance of a peeled orange. Perhaps after the Moon's surface began to solidify it was shaken from within by a terrific explosion, so that lava and molten matter poured through the cracks, cooling and hardening as seams of rock. This is what occurs when great eruptions occur on Earth as at Etna and Vesuvius. The state of the surroundings of the great Tarawera eruption in New Zealand, when the marvellous



THE EARTH AS SEEN FROM THE MOON
From "In Starry Realms," by Sir Robert Ball

Pink Terraces were engulfed, gives a good illustration of the after-effects of such violent outbreaks.

Bright streaks, though shorter than those of Tycho, also radiate from the great lunar crater Copernicus, the grandest scene on the Moon, especially when observed with a fine telescope. It is about fifty-six miles in diameter and surrounded by a circle of ridges, terraces, and precipices, its outer wall rising in the east about twelve thousand feet above the inner floor. The slopes are very steep, cliff falling below cliff, until the bottom of this fearful abyss is reached. To descend these cliffs or to scale their dizzy heights would be a memorable feat for a mountaineer.

One of the largest lunar craters is named Plato; it is specially interesting as it is said to be the darkest spot on the surface of the Moon. Here we can imagine Ali Baba and the Forty Thieves awaiting unwary travellers as they emerge from the sunlight into the blackest of nights. Not only has Plato, which by the way is one hundred miles in diameter, the reputation for being the darkest spot on the Moon, but Mr Serviss suggests that this may be the region referred to by the great Italian poet Ariosto, who affirmed that there is a place on the Moon where everything that is lost on Earth can be found. Maybe this is where his brave knight Astolpho went in search of the lost wits of his master. Ariosto tells us that he found them enclosed in a small bottle, together with hundreds of other bottles containing the lost wits of other Earth-dwellers, who had not even missed them.

Just beyond Plato are the Alps, their highest peak rising to some twelve thousand feet. Farther on still are the Apennines, the greatest of the lunar mountains. They extend to a distance of four hundred and sixty miles, and contain a peak twenty-one thousand feet high, although this is not the highest mountain on the Moon. One peak rises to a height of thirty thousand feet. At

the time of First Quarter the highest peaks in the range are seen tipped with sunlight, as from searchlights playing on the dark side of the Moon.

Could we stand on the loftiest peak of the Apennines at the time of New Moon, a scene of exceeding beauty would meet our eyes. While at our feet would be desolation—not a tree, a flower, or even a blade of grass to relieve the dreary monotony—overhead in a sky of inky blackness would ride our planet Earth shining in a blaze of reflected sunlight. Picture the Full Moon, but thirteen times as large, its surface tinted with the blue of oceans and the green, brown, and yellowish hues of forest-land and desert as revealed through cloud openings. Dazzling snowfields glistening at the arctic regions would complete a picture of the Earth as it would appear to our astonished eyes.

Had the Moon an atmosphere such as surrounds the Earth the whole of the lunar sky would be aglow. The Moon has no sky, but its mountains, hills, and valleys are illumined with the subdued splendour of Earth-light:

> And the innumerable heavens
> Break open to their highest, and all the stars
> Shine.

CHAPTER III

LEGENDS OF THE MOON

NEARLY a hundred years ago the whole world was startled by the news that Sir John Herschel, a great astronomer, who had gone to the Cape of Good Hope to explore southern skies with his large telescope, had made some wonderful discoveries. So powerful was his magic glass that it brought the Moon within arm's length ; he could not only see the wonderful scenery, but the inhabitants of the Moon as well.

The story was illustrated with pictures of strange bat-like creatures provided with wings, which enabled them to fly from place to place, or hover over the summits of steep precipices. Flocks of these winged beings were seen at times descending from the cliffs with slow, even motion to the plains below. They were four feet in height, and were covered, except on the face, with glossy copper-coloured hair. Their wings when out-spread for flight resembled those of a bat, for which reason they were called bat-men. When they alighted on the ground the wings could be folded, lying snugly upon the back and reaching to the ground. These Moon people seemed to be very happy and playful; they spent their time flying, bathing, or in collecting fruit and flowers.

They lived in huts, situated in valleys surrounded by hills scarlet in hue, and fluted like the columns of Fingal's Cave. Steep inclines were to be seen covered with a dark red flower like a poppy, the first flower ever seen on the Moon. There were also rocks of green marble, beyond which stretched beaches of glistening white sand, over

which the deep blue water of seas and bays broke in large white billows.

A lofty chain of slender pyramids of faint lilac hue, glistening in the sunlight, was also observed. The peaks rose to a height of eighty or ninety feet, and seemed like glowing spires situated amid enchanting valleys, or partly hidden by the dark green woods beyond. Here

MOON PEOPLE WITH WINGS AND FUR

From a drawing published in 1835

there were palm-trees adorned with large crimson flowers, gigantic trees like oaks, but with broad, glossy leaves and tresses of yellow flowers hanging from the branches to the ground. Farther on vast plains were revealed, on which gambolled goats with beards and horns, and endowed with the grace of an antelope. One of the observers amused himself by touching the part of the screen upon which these scenes were reflected from the magic glass, and the goats would suddenly bound away "as if conscious of our earthly impertinence," according to the account given supposedly by Sir John Herschel.

He was also said to have seen miniature zebras, long-tailed birds like golden pheasants, and a flock of sheep,

but no shepherd with blue apron and rolled-up sleeves looking after them. A strange creature, round like a ball, was observed rolling along a pebbly beach with great velocity, finally disappearing among the breakers on the shore.

In the valley of Ruby Colosseum, where the bat-men lived, was a temple of polished sapphire, or some resplendent blue stone, displaying myriad points of golden light reflected from the Sun. The roof of the temple was composed of some yellow metal, curved and resembling masses of golden flames rising in waving points from a great fire within. The structure was one hundred feet high from its glistening white floor to its glowing roof, and it stood upon the summit of a green hill in the centre of the valley. Flocks of white doves were constantly alighting upon its pinnacles, a finishing touch to the picturesque scene.

Such is a brief account of the quaint story of what is famous as 'The Lunar Hoax.' It was so cleverly written that it was generally accepted, almost without question. It aroused world-wide interest, until it was discovered to be nothing more or less than a hoax written by Mr Richard Adams Locke, in 1835, for the New York *Sun*, of which he was at that time the editor.

* * * * * * * *

Who has not heard of the Man in the Moon? Many are the legends told about this mysterious and lonely inhabitant of that distant orb. Some say that he was a wood-stealer, who during Church time on the Sabbath went into a wood to hew branches off the trees. He cut a faggot, slung it over his shoulder, and started homeward with his burden.

On his way he met a stranger who said to him:

"Do you know that this is Sunday, when all must rest from work?"

"Sunday on Earth, or Monday in heaven, it's all one to me," replied the woodcutter.

"Then bear your bundle for ever," answered the stranger, "and as you value not Sunday on Earth, yours shall be an eternal Moonday in heaven. You shall stand evermore in the Moon, a warning to all Sabbath-breakers."

Thereupon the stranger vanished and the man was caught up with his staff and faggot into the Moon, where he stands to this day.

According to another fable, the man was given the choice of burning in the Sun or of freezing in the Moon; and preferring a lunar frost to a solar furnace, he is to be seen at Full Moon with his bundle of sticks on his back.

Shakespeare refers to the Man in the Moon in *A Midsummer Night's Dream*, Act III, Scene I, where Quince gives directions for the performance of "Pyramus and Thisbe," by moonlight:

> One must come in with a bush of thorns and a lanthorn, and say he comes to disfigure, or to present, the person of Moonshine.

In Act IV of the same play the player of Moonshine says:

> All that I have to say is, to tell you that the lanthorn is the moon; I, the man in the moon; this thorn-bush, my thorn-bush; and this dog, my dog.

Shakespeare refers again to the Man in the Moon in *The Tempest*, Act II, Scene II, when Caliban and Stephano are conversing with each other:

> *Caliban:* Hast thou not dropp'd from heaven?
> *Stephano:* Out o' the moon, I do assure thee: I was the man i' the moon, when time was.
> *Caliban:* I have seen thee in her, and I do adore thee: my mistress show'd me thee, and thy dog, and thy bush.
> *Stephano:* Come, swear to that; kiss the book: I will furnish it anon with new contents; swear.
> *Trinculo* (a Jester): By this good light, this is a very shallow monster! I afeard of him! A very weak monster! The man i' the moon? A most poor credulous monster! Well drawn, monster, in good sooth!

Cyrano de Bergerac declared when asked where he had come from : " From the Moon. A hundred years ago, or else a minute—for I have no conception how long I have been falling—I was up there, in that saffron-coloured ball."

According to a Dutch legend, the Man in the Moon was placed there as a punishment for stealing cabbages on Christmas Eve. The neighbours caught him just as he was walking away with a good supply, and they ' wished ' him up in the Moon. He has been there ever since, bearing his load of cabbages, and is supposed to turn round once on Christmas Eve.

The rustic in the Moon
Whose burden weighs him down,
The changeless truth reveals
He profits not who steals.

Apparently he was not satisfied with stealing cabbages, for in Scandinavia there is a story about two children snatched by him up to the sky. They were on their way to the well, carrying a pole and bucket on their shoulders, when the Man in the Moon saw them. They pleased him so much that he could not resist the temptation of stealing them, saying to himself :

" How they please me! How they tempt me!
Shall I snatch them up to-night ?
Snatch them, set them here forever
In the middle of my light?
Children, aye, and children's children,
Should behold my babes on high ;
And my babes should smile forever,
Calling others to the sky."
Thus, the philosophic Moon-man
Muttered many years ago ;
Set the babes with pole and bucket,
To delight the folks below.
Never is the bucket empty,
Never are the children old ;
Ever when the Moon is shining
We the children may behold.

This recalls the well-known nursery rime of " Jack and Jill," which dates back to one of the oldest myths in the world. The names of the Norse Moon-children were Bil, which can easily become Jill, and Hjuki, pronounced Juki, which could as readily become Jack. Little did we know when repeating the nursery jingle,

Jack and Jill went up the hill,
To fetch a pail of water ;
Jack fell down and broke his crown
And Jill came tumbling after,

that it referred to the dark spots on the Moon. The fall of Jack and the subsequent fall of Jill simply represent the vanishing of one Moon-spot after another, as the Moon wanes. The legend of Hjuki and Bil, therefore, represents the waxing and waning of the Moon, and the water they are carrying in the bucket suggests that the rainfall depends on the phases of the Moon.

Then there is the Lady in the Moon. Have you seen her ? She occupies all the central portion of the western half of the disk, and is well worth looking for. She wears a wondrous jewel at her throat—the volcano Tycho—its rays shooting in all directions as a diamond flashes light from its facets. A string of brilliants adorning her hair is furnished by the lunar Apennines, the peaks gleaming like polished steel. Her hair is formed out of the vast grey plains. But approach her carefully ; she must be seen from the right point of view or she vanishes.

The Chinese have a legend of Chang-o, a beautiful fairy queen who resides in the Palace of the Moon. Her throne is of gold, above which rainbow-winged angels form a canopy. A host of fairy beings stand before her, dressed in white and glistening with star-dust.

For always wanting to know when the world would be ended, a woman was placed in the Moon. According to an American Indian legend, she weaves a forehead strap, and when it is finished her question will be answered. Near the end of the month, when she is about to finish

her task, she stops for a minute to stir a mess of hominy in a saucepan, and a cat which always sits beside her takes the opportunity to unravel her work. Thus she has to begin all over again.

Not only do we hear of a Man in the Moon, and a Woman in the Moon, and a cat in the Moon, but of a hare, and a toad. You may like to hear about them as well. The hare is sacred to Chandra, the name of the Hindu Man in the Moon. According to a Buddhist legend told by the people of Ceylon, Buddha while living on earth as a hermit one day lost his way in a wood. He wandered about for a long time until he met a hare, who offered to show him the way out of the wood.

THE WOMAN WHO WANTED TO KNOW WHEN THE WORLD WOULD BE ENDED

"Strike into the path on thy right," said the hare, "and I will guide thee out of the wilderness."

"I thank thee," replied Buddha, "but I am poor and hungry, and unable to repay thy kindness."

"If thou art hungry," said the hare, "light a fire, and kill, roast, and eat me."

Buddha made a fire, and the hare immediately jumped in. But, overcome at the unselfishness of the hare, Buddha snatched it out of the flames and set it in the Moon. In another legend of India the hare dwells upon the shore of a lake in the Moon, where the king has his palace. The Moon is described as a watcher of the sky who sleeps with her eye open like the hare.

THE CRATER COPERNICUS
Taken at Yerkes Observatory with the 40-inch reflector
[See p. 56]

SECTION OF THE MOON, SHOWING THE APENNINES, CRATER OF PLATO, AND THE SEA OF SHOWERS
Taken at Mount Wilson Observatory with the 100-inch reflector
[See p. 56]

MOUNTAINS ON THE MOON
[See p. 341

Legends of the Moon

According to an Eskimo myth, when the world was young the Sun and Moon were brother and sister and lived on the Earth. One night when they were playing games in the dark with some other children Malina was much annoyed by one of the boys who teased her. Smearing her hands with soot from a lamp she rubbed them over his face, so that she might know him by daylight, and tell her brother to punish him. When daylight came she was so frightened when she found that it was her own brother Anninga who had teased her, for his face was smeared with lamp-soot, that she ran away.

Anninga ran after her, until they came to the place where the Earth and sky meet. Then they both flew upward to the sky. Malina became the Sun and Anninga became the Moon, but being unable to fly so high as his sister, he runs round the Sun all the time in the hope of some time surprising and catching her.

When he is tired and hungry he harnesses four huge dogs to a sledge, and hunts for several days. Then he cannot be seen in the sky. On his return he eats so much that he soon grows into a full, round Moon. If you look at him on a clear night, you will see the spots of lamp-soot which his sister smeared on his face.

The toad in the Moon is a quaint tradition found among the records of the Selish races of North-west America. It seems that a little wolf, being desperately in love with a toad, went a-wooing one night. He prayed that the Moon might shine on his path. The prayer was granted, and by the light of the Full Moon he pursued his beloved and had nearly caught up with her when she made a desperate leap on to the Moon, where she may be seen to this day.

But the Moon is not always so obliging, as appears in the New Zealand myth of Rona. We are told that Rona went to a well one night to get some water. The Moon was shining brightly so that she could see where she was going, but presently a cloud cut off its light. Just then

Rona stumbled over a log, and she was so angry that she exclaimed, "Boil the Moon!" Imagine her horror when she saw the Moon approaching her! She caught hold of a tree and clung to it, but it gave way and with Rona was transported to the Moon. There Rona keeps company with the grandmother of Hiawatha. According to the poet Longfellow, the hero

> Seized his grandmother, and threw her
> Up into the sky at midnight;
> Right against the moon he threw her.
> 'Tis her body that you see there.

Once upon a time, according to an ancient Sanskrit fable, a mighty elephant named Toothy lived in a forest. No rain had fallen for a long time, and the pools and swamps had dried up, so Toothy sent out scouts in search of water. One of these, a little elephant, found the Moon-lake within a circle of trees, and he brought the mighty elephant, followed by the whole herd, to what they hoped would prove to be an unending supply of water.

Unfortunately, there were a number of hare warrens in the sandy soil round the lake, and the elephants trampled upon these, and several hares were crushed beneath their ponderous feet.

When the herd had drunk their fill and withdrawn, the hares assembled and bewailed the ruin of the warrens. Moreover, they feared that worse was in store, for as there was no water elsewhere they knew that the elephants would return, and that would be the death of all.

But Long-Ear, their wise and prudent leader, had thought of a plan by which he could avert the threatened danger, and when the herd came again to the lake he boldly faced their king and said:

"Ha, ha! bad elephant! what do you mean by coming here with all your family to this strange lake? Be off with you at once!"

When the King of the Elephants heard this strange

address, he trumpeted with rage and exclaimed, "Pray, who may you be, who dares address me—the King of the Elephants—in this impudent way?"

"I am Vidsehajadatta," replied Long-Ear, "the hare who resides in the Moon. I now speak to you as ambassador of His Excellency the Moon."

"Ahem! Hare," returned the elephant, somewhat staggered, "and what message have you brought me from His Excellency?"

"You have maimed some of my hares. They are my subjects, and if you value your life you will not dare to venture near the lake again. Break my command, and I shall withdraw my beams from you at night, and your body will be consumed by unending heat from the Sun."

The elephant replied, "Friend! it is true that I have acted against the rights of His Excellency. I wish to make an apology. How can I do so?"

Said the hare: "Come with me and I will show you."

"Where is His Excellency at present?" asked the elephant.

"He is now in the lake," the crafty hare replied, "hearing the complaints of the maimed hares."

"If that be so," said the elephant humbly, "bring me to my lord, that I may ask for his forgiveness."

So the hare led the King of the Elephants to the edge of the lake, and lo! the Moon was reflected upon its clear surface.

"There stands my lord the Moon plunged in meditation; reverence him, and then depart in peace!"

Thereupon the elephant poked his trunk into the lake and uttered a fervent prayer. The action set up ripples in the water, so that the reflection of the Moon became all a-quiver.

"Look!" exclaimed the hare, "His Excellency is trembling with rage."

"Why is his Supreme Excellency angry with me?" asked the awed elephant.

" Because you have set the water in motion. Worship him, and then be off with you ! "

The elephant drooped his ears, bowed his great head to the earth, and in suitable terms expressed his regret for having annoyed the Moon and trampled upon his hares, and he vowed never to trouble the Moon-lake again. And since that day the hares have lived unmolested upon its quiet shores.

There are endless variants of the story explaining the dark patches on the surface of the Moon, but the most poetical idea concerning our satellite was that held by the Druids. According to their belief the Moon was Paradise, the eternal abode of the Blest. There they expected to meet their friends and carry on business as on Earth. They believed in this so strongly that we are told they borrowed from each other, promising to repay in the next world.

The Druids pictured the Moon with lunar brooks stirred by soft breezes, and the air laden with the sweet perfumes of flowers. What a charm such a belief must have given to the heavens at night as men lifted their eyes to the lunar Paradise ! But the Moon was supposed to be the residence of happy souls only ; others who approached it were flung back by the waves of a mighty whirlwind.

Because of this belief the Moon occupied a prominent place in the religion of the Druids, who placed it second to the Sun. Festivals were arranged in its honour, and the Druids are always represented as having crescents in their hands, symbols of the crescent Moon.

In the seventh and early in the eighth century the Moon was one of the objects of heathen worship in Britain. The goddess with whom the people associated it is not known ; it may have been Andraste, the goddess to whom the British queen Boadicea, with hands outstretched to heaven, appealed when about to engage in battle with the Romans.

CHAPTER IV

THE CHILDREN OF THE SUN

THE planets are the children of the Sun,[1] around whom they circle, ever obedient to his control. There are four large planets, Jupiter, Saturn, Uranus, and Neptune ; and four small planets, Mercury, Venus, the Earth, and Mars. Besides these there are many tiny planets which may be said to be in the kindergarten stage. These little fellows are sometimes referred to as planetoids, asteroids, or ' pocket-planets,' and they pursue their heavenly way in the space between Mars and Jupiter. We shall hear more about this solar kindergarten later.

The names of several of the planets are preserved in the names of the days of the week. This is more easily seen in French, as the following list shows :

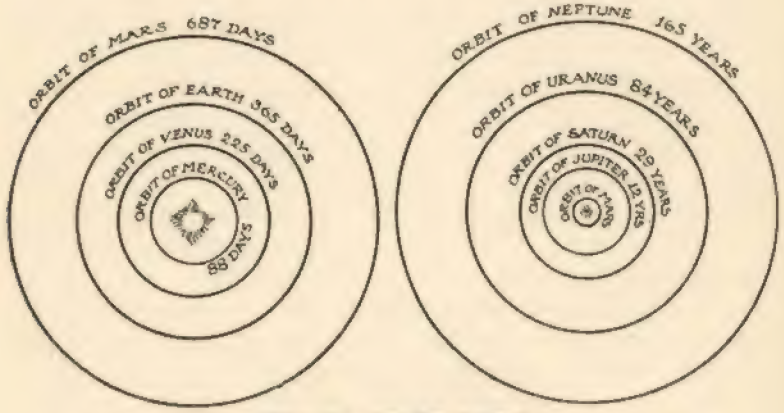
Tuesday . . .	Mardi	or Mars' day.
Wednesday . . .	Mercredi	or Mercury's day.
Thursday . . .	Jeudi	or Jove's (Jupiter's) day.
Friday	Vendredi	or Venus' day.

Our ' Tuesday,' ' Wednesday,' ' Thursday,' ' Friday,' are called after the Scandinavian counterparts of Mars, Mercury, Jupiter, and Venus. ' Saturday ' is ' Saturn's day.' ' Monday,' of course, is ' Moon-day,' and ' Sunday ' is ' Sun-day.'

To make a chart of the Sun and his family the Sun should be placed in the centre, encircled by the planets Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. So far, no moons have been discovered as companions to Mercury and Venus, but the Earth, as we

[1] They were formed out of the same cloud of gas from which the Sun itself was born.

know, has one, Mars has two, Jupiter has nine, Saturn nine (possibly ten), Uranus has four, and Neptune—the sentinel on the borders of the Solar System—has but one to keep it company during its solitary round, which takes 165 years to complete. Over this large family, Neptune the outermost being at a distance thirty times as great as that separating the Sun from the Earth, or 2,800 million miles, the Sun exercises a fatherly control.



THE SUN AND HIS FAMILY
(Arranged for convenience in two groups. The smallest circle in the diagram on the right corresponds to the largest circle in the diagram on the left.)

All the planet children are inclined to be independent and to wander off by themselves, but Father Sun keeps a firm hold on them; not by means of chains or bonds, but simply by that wonderful power of gravity which holds the family together.[1] The attraction between the Sun and the Earth is equal to a strain capable of breaking a steel rod about 3,000 miles in diameter. If the Sun did not hold on to the planets they would come to grief.

The Sun, as we have already seen, supplies the light and heat which make our planet a comfortable abode for human beings. He is especially generous to the nearest planet, Mercury, because it is so much closer to him; on

[1] See p. 52.

the other hand, more distant planets receive less, and the supply dwindles as it makes its way to the frontiers of the Solar System. So we are fortunate in being on planet Earth, instead of on far-away Neptune.

The planets are inclined to tug at each other, Jupiter pulling Saturn, Mars pulling Jupiter, so that with the pull from the Sun their paths are not the neat circles one can draw with a compass, but ellipses, the beautiful curves discovered by Greek mathematicians.

An ellipse can be easily drawn with the assistance of a piece of twine and two pins. Put a sheet of paper on a drawing-board, or any board that is handy. Fasten it down with two pins separated by a few inches. You will probably find a piece of twine in your pocket, but it must be twice the length of the distance between the pins. Tie the two ends together and put the loop over the pins. Place your pencil inside the loop and move it along the twine, round the pins, keeping the twine taut all the time. The two points where the pins are placed are called the *foci* of the ellipse that you will have drawn. As a planet moves round the Sun, the Sun is in one focus of its ellipse.

DRAWING AN ELLIPSE

A story is told of a lady who heard Sir Robert Ball describe how an ellipse is drawn, and how the Sun is in one focus of the ellipse. At the conclusion of the lecture, when questions were asked by members of the audience, the lady asked in which focus was the Sun to be found. With his usual ready wit Sir Robert Ball replied: "The right one."

Another story was told by him of three boys who were taking an examination in astronomy. Anxious that they should pass, he made the questions very easy.

He said to the first boy: "Can you tell me, does the Sun go round the Earth, or the Earth go round the Sun?"

The boy replied that the Sun went round the Earth.

Sir Robert repeated the question to the second boy, who, guessing from the expression of the examiner's face that the first answer was incorrect, glibly replied that the Earth goes round the Sun. Sir Robert now came to the third boy, who had been waiting in fear and trembling for his turn ; he was so anxious that no margin should be left for a probable error in his answer that he promptly replied : " Please, sir, sometimes it's one way, and sometimes the other."

The story of how people gradually learned that the Earth was not flat, that the planets were not gods, and that the Sun-god did not make a daily journey across the sky in his golden chariot, is full of interest, and the man who may be said to have put the Sun in its right place was named Copernicus.

Copernicus was a quiet, scholarly monk who lived during part of the fifteenth and sixteenth centuries at Frauenburg, near the mouth of the Vistula. As a result of deep thought, careful study, and some wonderful calculations, he proved that the Earth was not the centre of the Universe, but a planet revolving round the Sun, which was in turn the central pivot of the planetary system. He thus not only swept aside all the quaint ideas of the ancients, but those as well of Ptolemy, who taught astronomy in Alexandria about 140 A.D., and whose teachings were accepted as the highest authority for the next fourteen centuries.

According to Ptolemy, as set forth in his book on astronomy called the *Almagest*, the Earth was stationary and at the centre of all things. Around it revolved the celestial vault carrying the stars, and within the vault the Sun and Moon revolved around the Earth with steady movement, and the planets in curiously looped paths:

> Their wandering course, now high, now low, then hid,
> Progressive, retrograde, or standing still.

Moreover, the celestial vault was said to be surrounded by eleven skies, above which was " the abode of the blest."

When Copernicus advanced his new theory, which dethroned the Earth from its central position in the Universe, believers in the system of Ptolemy refused to accept an idea so opposed to the teachings of their great master. Indeed, if you will try to appreciate the effect of this discovery you will easily understand how amazing it must have appeared to the 'old-fashioned' minds of the time. Sir Oliver Lodge remarked during a lecture given by him in 1887 :

" The doctrine is very familiar to us now. We have heard of it since we were four years old, but can you realize it ? I know it was a long time before I could. Think of the solid Earth, with trees and houses, cities and countries, mountains and seas—think of the vast tracts of land in Asia, Africa, and America, and then picture the whole mass spinning like a top, and rushing along its annual course round the Sun at the rate of nineteen miles every second."

Were we not accustomed to it, the idea would be staggering. No wonder people found it difficult to believe. Copernicus had the satisfaction of completing his book, in which he had carefully explained his wonderful theory, but the first printed copy was placed in his hands only as he was dying ; though he could not read it, at any rate he had the satisfaction of feeling it before he passed away.

Among those who held that Copernicus was wrong was Tycho Brahé, who was born in 1546, and died in 1601. He argued that it was difficult to believe that if the Earth moved upon a course or spun round upon its axis a stone or other dropped body would not be left far behind. For example, to take a modern instance, an airman ascending to a great height and remaining in the air for an hour or more might have the uncomfortable experience, on attempting to return, of finding that the Earth had left him far behind. Since, as already remarked, the distance traversed by the Earth every second

in the course of its annual journey round the Sun is nineteen miles, then, during the course of an hour, it would have gone forward over sixty-eight thousand miles!

Another objection made by Tycho Brahé was that if the Earth revolved round the Sun, then Mercury and Venus travelling on an inner track should show phases like the Moon. So they do, but a telescope is needed to detect the phases, and the telescope had not yet been invented. Copernicus very wisely replied that it might be impossible to see the phases without extra power of sight, and again he was right. It is interesting to note that the phases are seen reversed in the telescope, which recalls the story of a visitor to an observatory who was not only interested in astronomy, but gifted with a vivid imagination. He was shown the planet Venus, then passing through the crescent phase. After withdrawing from the telescope he suddenly exclaimed :

" Oh ! I can see the crescent."

Being asked to make a drawing of what he could see with the unaided eye, he was surprised to learn that he could not possibly have seen what he had drawn in his sketch, which showed the phase reversed.

" But why ? " he asked in surprise.

" Simply because the phase is reversed in the telescope. If you could see it with the unaided eye it would appear the other way round."

Another objection Tycho Brahé had was that the stars could not be placed at the enormous distances assigned to them by Copernicus, for though the Earth sweeps round the Sun in a mighty orbit, their positions with regard to each other remain unchanged. " If this amazing theory were true," said Tycho, " the stars would be hundreds of millions of miles from us, which is monstrous and incredible." But the absurdity of making the whole gigantic system of Sun, planets, and stars revolve round our tiny Earth was too obvious, and was soon abandoned.

Though his theories were out of date, Tycho Brahé was a great man. He is honoured as the founder of the splendid system of practical astronomy which is at the root of the work of all modern observatories.

He introduced marvellous accuracy, though his measurements were made with the crudest instruments.

TYCHO BRAHÉ'S OBSERVATORY AT URANIBORG

This gives point to a great astronomer's remark that a skilful observer ought to be able to make valuable measurements with a common cart-wheel! At any rate, the observations recorded by Tycho Brahé were such marvels of accuracy that not a single mistake due to carelessness has ever been detected in them.

Let us glance at a picture which shows this fine old astronomer in the magnificent observatory, known as Uraniborg, or Castle of the Heavens, on the island of Huen in the Baltic. Frederick II, King of Denmark, provided the money for the erection of this observatory and presented it when completed, together with the site,

to the astronomer. The walls were decorated with pictures, and we see Tycho in his velvet robes of state, as though in the presence of princes. He is seated on a chair facing an opening in the wall, through which he is pointing toward a planet which has probably just come into view. An assistant is sliding the pointer on a quadrant upon which a number of figures are engraved, and is calling out the number to which the pointer is directed to another assistant, who is seated at a table with a book before him, in which he is to record it, together with the time at which the observation was made. This is to be given to him by a third assistant, who is looking at the clock. The picture illustrates the entire process of indicating the position of a heavenly body, which comprises two observations, one from the circle, and the other from the clock, the principle in use to this day.

A great Danish hound is stretched at Tycho's feet. It was given him by the King, and was the innocent cause of Tycho's expulsion from the observatory some years later. During the lifetime of Frederick II a courtier ill-treated the dog. Tycho, who was apt to be fiery and quarrelsome, told the courtier very plainly what he thought of him, which the courtier resented. However, he waited until Frederick had died, and then by a series of petty attacks he succeeded in bringing Tycho into disfavour, and eventually was the cause of his leaving the island.

However, during the earlier part of his career Tycho devoted all his energies to the pursuit of the work which has made his name famous. He was not only accurate, but persevering, which explains why, though provided with very poor tools, he was able to perform wonders. He was specially interested in tracing the path of the planet Mars in its wanderings round the Sun. Week after week, month after month, year after year, did the patient old astronomer track its path, but it persisted in

straying from the circular path along which it was supposed to travel, so that with all his skill and patience Tycho was baffled.

Fortunately he had a clever pupil named Kepler, who was possessed of keen imagination, great perseverance, and endless patience in pursuing the errant planet.

Again and again Kepler attacked the problem, but it was not until he realized that the path pursued by Mars was not a circle that he began to suspect the truth. He had devoted eight years to a close examination of every combination of circular motion his imagination could suggest, but the secret remained a secret still. But one thing he had learned: the path was not a circle; that was something gained.

Leaving the circle, he set out to follow the planet over an ellipse, but although it proceeded very nicely for a short distance it soon swerved off the track, bidding defiance to the patient watcher. We can see him sharpening his pencil ere sitting down to a new set of observations and further long hours of thought as to the cause of the erratic behaviour of Mars.

Finally, he discovered his error. He had been taking it for granted that the Sun occupied a central position in the ellipse. Not in the least disheartened by his former failures, he started off on his search again, this time shifting the Sun in his calculations to the focus of the ellipse. (Look at your chart of an ellipse; one of the pins will represent where the Sun would be, according to the calculations made by Kepler.)

Week after week he watched the planet as it swept onward round the Sun. Half the revolution had been performed, and the planet had not swerved. It continued on its way, always keeping on the track, and finally returned to the starting-point. Triumph had crowned the efforts made by the great philosopher; after eighteen years spent in a seemingly fruitless search, and despite ill-health and poverty, he had probed one of

Nature's deep secrets. It was one of the most important discoveries ever made, leading to the formation of what is known as Kepler's law: "Planets revolve in elliptic orbits[1] about the Sun, which occupies the common focus of all these orbits."

So rejoiced was he when success crowned his efforts that he broke out exultingly: "Nothing holds me; I will indulge my sacred fury. If you forgive me, I rejoice; if you are angry, I can bear it; the die is cast, the book is written, to be read either now or by posterity, I care not; it may well await a century for a reader, as God has waited six thousand years for an observer!"

Kepler found that Mars moved much more rapidly when nearest the Sun than when at its greatest distance, thus reversing the 'safety first' rule, whereby the driver of an engine or car slows down when he is approaching a sharp curve. Why Mars was so capricious Kepler did not know, and it remained for Sir Isaac Newton to solve the problem, which he found depended upon the great law of gravitation.

A planet is compelled to increase its speed when nearest to the Sun in order to resist being drawn inward upon its surface. After rounding the critical curve it slackens speed, and is in danger of getting beyond the Sun's warmth and guidance as it approaches its greatest distance from the Sun, but the latter overcomes, by its attractive power, the planet's desire to fly outward into space.

If the planets are attracted by the Sun, what keeps them from falling into the Sun? Why does not the Moon tumble on the Earth? It is the fact that the planets are *moving*, and that the Moon is *moving*, which has enabled these bodies to resist the attraction, in so far, at least, that they are not drawn thereby to total destruction.

[1] See page 71.

For a long time a planet was supposed to circle between Mercury and the Sun, and this was given the name of Vulcan.

On March 26th, 1859, Dr. Lescarbault, a country physician, living some eighty miles from Paris, announced that nine months before he had actually seen the planet as a spot, quite round and black, passing across the face of the Sun.

When the news reached the great French astronomer Leverrier, he expressed surprise that nothing had been said about the discovery before, and he immediately set out for the home of Lescarbault. According to the account given by Abbé Moigno, the interview must have been rather trying.

"One should have seen M. Lescarbault," says the Abbé, "so small, so simple, so modest, and so timid, in order to understand the emotion with which he was seized, when Leverrier from his great height thus bluntly addressed him: 'It is then you, sir, who pretend to have observed the intra-Mercurial planet, and who has committed the grave offence of keeping your observations secret for nine months. I warn you that I have come here with the intention of doing justice to your pretensions, and of demonstrating that you have been either dishonest or deceived. Tell me, then, what you have seen.'"

This singular address, according to Abbé Moigno's account, did not bring the interview to an end, as one might have expected. The doctor trembled, it is true, but bravely stammered through a statement of what he had seen. He explained how he had timed the passage of the black spot.

"Where is your chronometer?" asked Leverrier severely.

"It is this watch, the faithful companion of my professional journeys," answered the doctor proudly.

"What! with this old watch, showing only minutes,

dare you talk of estimating seconds?" thundered the angry astronomer. "My suspicions are only too well confirmed."

"Pardon me," remarked the doctor meekly, "but I have a pendulum which beats seconds."

"Show it to me!" shouted Leverrier, scarcely able to control his wrath at the doctor's apparent attempt to impose upon him.

Abbé Moigno then relates how the doctor brought down a silk thread to which an ivory ball was attached. He fixed the upper end to a nail, drew the ball a little from the vertical, counted the number of oscillations, and showed that his pendulum beat seconds. He also explained how his profession required him to feel pulses and count pulsations, so that he had no difficulty in mentally keeping records of successive seconds. He then showed the telescope he had used, the record of the observation on a sheet of paper which served as a marker in a French nautical almanac, and the rough attempts he had made in calculating the planet's distance from the Sun on a rough board in his workshop.

"For," said he, modestly, "I am a joiner, as well as an astronomer."

Leverrier was now satisfied that a new planet travelling between Mercury and the Sun had been actually discovered. He congratulated Lescarbault on the important discovery he had made, and caused the decoration of the Legion of Honour to be conferred upon him. The name of Vulcan was assigned to the new planet by Abbé Moigno, and its diameter was estimated by Leverrier as being about 2,500 miles.

Nothing more was heard of the planet until in August 1876 Herr Weber, an observer of considerable skill, stationed at Pecheli, in China, announced that he had seen it, but a photograph taken at Greenwich Observatory on that date proved beyond doubt that the object was an ordinary, everyday sunspot. During the total eclipse

of the Sun in 1878 an American astronomer, Professor Watson, announced that he had seen two starlike objects near the Sun, but they were probably the two stars Theta and Zeta in the constellation Cancer. Dr Swift, another American observer, announced that he had seen two bright stars, but that they were in a different part of the sky; his observation has never been explained. A photographic search was made for the planet during the total eclipse of the Sun in 1905, but in vain, and 'Vulcan' has become more or less a myth.

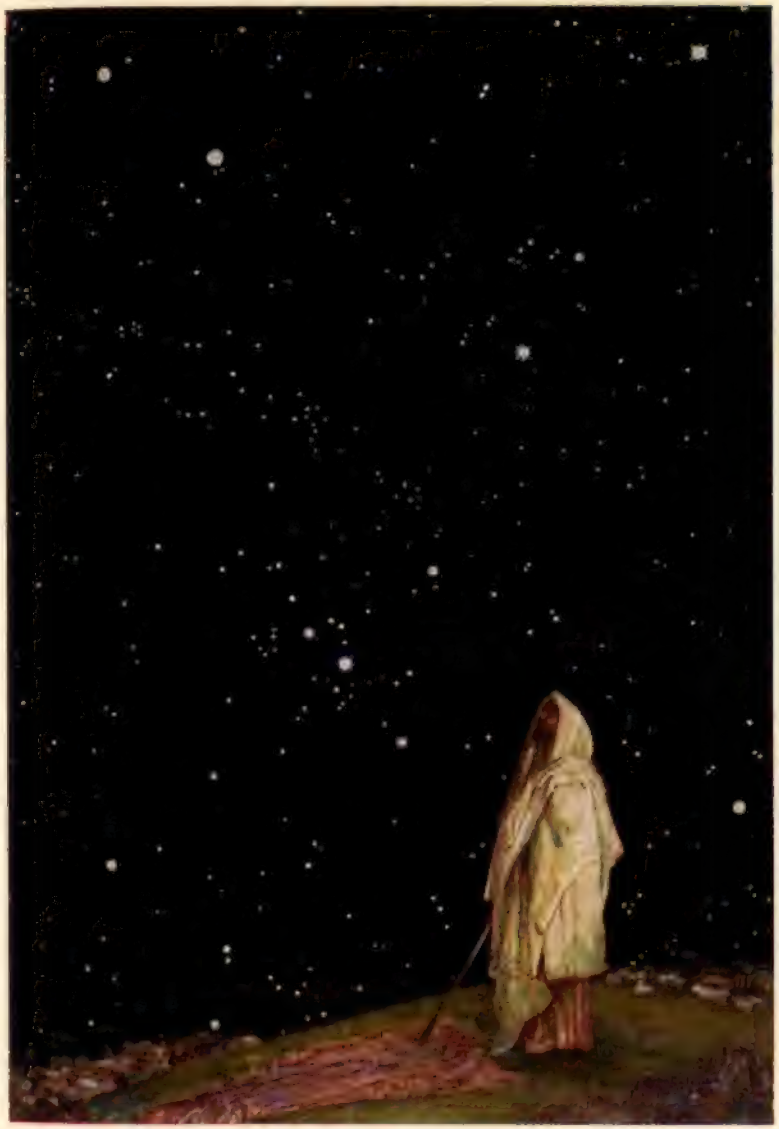
CHAPTER V

THE ROSY PLANET MERCURY

'THE rosy planet' is the shy little planet Mercury, which nestles so closely to the Sun as almost to be lost in its glare. An astronomer has described it as appearing rosy in hue when seen through a telescope. The Greeks called it the Sparkler, or Twinkler. It was discovered long before the days of Kepler or Copernicus. No one knows the name of the discoverer, where he came from, or where he lived, but records going back to long ago refer to a report made by one of the chief astronomers of Nineveh to the King of Assyria, in which an allusion is made to Mercury.

Therefore we must fall back upon our imagination, and we see a lonely watcher of the skies guarding his flocks and herds either on the shores of Greece, or the vast desert plains of the East. During the long hours of the night he watches the stars brightening after twilight or fading before dawn. One evening his attention is attracted by a bright, starlike object glistening in the western sky which he had not noticed before. It only remains visible for a short while, and then slowly disappears below the western horizon. Next evening, it is there again, a little higher and brighter, disappearing somewhat later. Thus it continues rising higher and brightening, but always sinking again and disappearing. After a few evenings it begins to retrace its path, setting sooner each evening, until finally it is seen no more.

Doubtless the observer wonders what has become of the bright object, until one fine morning, just before

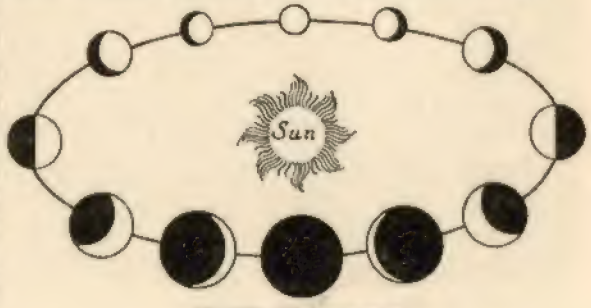


THE LONELY WATCHER OF THE SKIES
Evelyn Paul

sunrise, he sees a similar star in the eastern sky. It behaves in exactly the same way as the star seen in the west. He has no idea that it is one and the same. Probably it was long ere the two were connected.

Thus the Twinkler went by two names, the Greeks calling it 'Apollo,' when it was a morning star, and 'Mercury' when it was an evening star. It is so near the Sun that it is difficult to see it with the unaided eye. Copernicus complained that he had never been able to enjoy a view of it, and this was doubtless because he lived at Frauenburg, near the river Vistula, where the sky near the horizon is hazy owing to vapours and fogs.

Nowadays, if we wish to see Mercury all we have to do is to consult an almanac, which will tell us when the planet will be visible in the evening or in the morning sky.



PHASES OF MERCURY

Mercury is best seen in the springtime when it is well above the horizon, or in the evening twilight, about three-quarters of an hour after sunset, when it presents a very beautiful appearance in the evening sky.

In *Astronomy with an Opera-glass* Mr Serviss tells us that the beauty of the planet is greatly enhanced by the aid of an opera-glass: "Mercury is brilliant enough to be distinguishable, even while the twilight is still pretty bright, and I have had most charming views of the planet, glittering like a globule of shining metal, through the fading curtain of a winter sunset." Only to read that description makes one long to borrow an opera-glass. After all, there is nothing like seeing for yourself, and, of course, if you are so lucky as to know some one who

has a telescope, you may have a chance of seeing that Mercury shows phases like the Moon. This is because Mercury comes between the Earth and the Sun, just as the Moon shows phases because it comes between the Sun and the Earth.

When Mercury is at inferior conjunction,[1] that is, between us and the Sun, we cannot see the planet because

COMPARATIVE SIZE OF EARTH, MARS, MERCURY, AND THE MOON
From "In the High Heavens," by Sir Robert Ball

the bright side is turned away from us, but as it swings outward from that position we see it as a crescent, until when it has reached its greatest distance from the Sun it looks like the Half Moon.

By the way, learned folk call its greatest distance 'elongation,' a word derived from the Latin *e*, out, *longus*, long, = to lengthen. So if an almanac such as Whitaker's tells you that Mercury is at its greatest *elongation* east or west of the Sun, as the case may be, you will know what the term means, and that there is some chance of seeing the planet in the early morning, or evening sky, as the case may be.

[1] See diagram, p. 100.

Sometimes when Mercury is on the same side of the Sun as the Earth we can see it as a small black dot crossing the Sun's disk. This is called a transit of Mercury. The story of the earliest transit observed, which was in 1631, may be of interest. The name of the observer was Gassendi, and his observations were made in Paris. He wrote :

> The crafty god had sought to deceive astronomers by passing over the sun a little earlier than was expected, and had drawn a veil of dark clouds over the earth in order to make his escape more effectual. But Apollo [here Gassendi refers to the Sun-god], acquainted with his knavish tricks from infancy, would not allow him to pass altogether unnoticed. To be brief, I have been more fortunate than those hunters after Mercury who had sought the cunning god in the sun. I found him out, and saw him, where no one else had hitherto seen him.

Gassendi made preparations for observing the planet by making a small hole in the window of his darkened room, through which the image of the Sun could be cast upon a white screen on which he had drawn a circle adapted exactly to the size of the image. In order to fix the time, he placed an assistant in a room above him with a quadrant of 2 feet radius, charging him to observe the altitude, or height, of the Sun whenever he should hear him stamp with his foot.

In order that the transit of the planet might not escape him, he resolved to begin his observations two days earlier than the date assigned by Kepler. The first day it was rainy; the next, the sky was overcast all day ; the day when the transit was expected to take place was for the most part cloudy. A little before eight o'clock the Sun was visible through openings in the clouds, and toward nine o'clock the sky became clear.

Gassendi now saw a black spot upon the surface of the Sun, but he had no idea that this was Mercury because of its extreme smallness. He was inclined to think it was a Sunspot. However, he measured its distance from the

centre of the image, and measured again a little later, when he found that the spot had moved much nearer to the centre. This convinced him that the black spot was Mercury. Immediately he gave the signal to his assistant in the upper room, but unfortunately the latter had deserted his post and for some time could not be found. We can picture to ourselves Gassendi anxiously searching for him. Finally the truant returned, just in time to make the necessary observations before the planet had gone from its position before the Sun.

At another transit of Mercury which occurred in 1781, we are told that

> At sunrise, it rained; all the astronomers of France were at their telescopes, but fatigued while waiting they quitted their telescopes, half an hour after the time announced for the planet's egress from the Sun's disk.

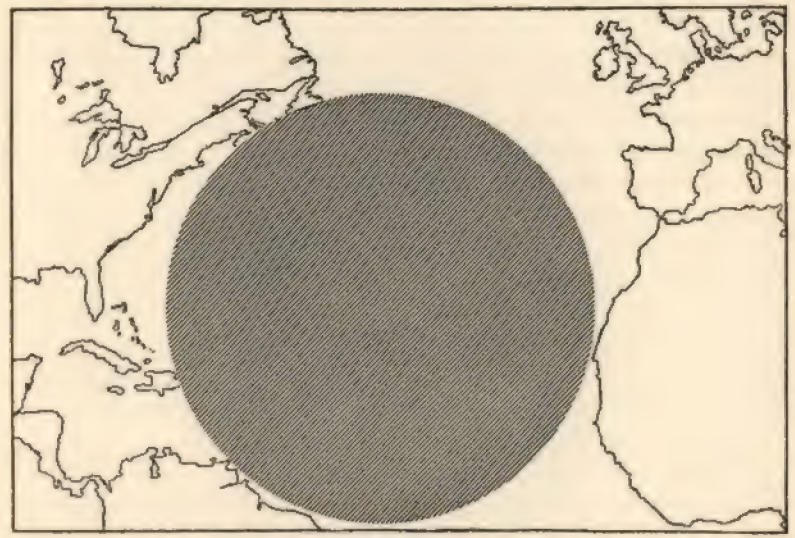
The actual transit took place three-quarters of an hour later than that fixed by the French astronomer Lalande, and three-quarters of an hour earlier than that assigned to it by the English astronomer Halley!

Even a wait of five minutes may seem endless, as appears in an account given by Professor Mitchell of the Cincinnati Observatory of his experience at the transit of Mercury which occurred in 1844:

> There I sat, with feelings which no one can realize, waiting for the transit. After remaining there for what seemed to be long hours, I inquired of my assistant how much longer I would have to wait; I was answered four minutes.
>
> I kept my place for what seemed an age, and again inquired as before. He told me that but one minute had rolled by. It seemed as if Time had folded his wings, so slowly did the moments crawl on. I watched on until I was told that but one minute remained, and within sixteen seconds of the time I had the most bewildering gratification of seeing the planet break the contact, and slowly move on till it buried itself round and deep and sharp on the sun.

The planet is not large enough to be seen without a telescope as it crosses the Sun's disk, and, moreover, care

must be taken to have the eyepiece of the telescope screened with dark green or smoked glass. Otherwise there is the danger of being blinded by the glare of sunlight, which was nearly my experience at the transit of Mercury which occurred on May 9th, 1907. I had an ordinary spy-glass such as people use at the seaside for



IF MERCURY WERE IN THE ATLANTIC

watching ships out at sea. Reading in the morning paper that the transit would occur at a certain time, which happened to be just about the moment I was reading, I hastily picked up the spy-glass, which lay handy, and turned it in the direction of the Sun.

I looked for a second or so, and saw or imagined I saw a black dot on the surface of the Sun. I have always hoped it *was* Mercury, but, as the Scotsman said, "I hae ma doots." It was probably only an everyday Sunspot, and my eye hurt me so much that I was not encouraged to make another attempt.

However, as the boy said at school, when asked to

translate *experientia docet,* " experience does it," and at the next transit of Mercury I knew better.

The planet Mercury has in all ages given more trouble to astronomers than any other of the larger planets of the solar system. This is not only because of its tiny size—it is the smallest in diameter (not quite 3,000 miles) —but on account of what is called the eccentricity of its orbit. Now we all know what eccentricity means ; eccentric people, for instance, are always surprising us by doing things in an unusual manner.

Instead of circling round the Sun in a fairly accurate circle, as most of the planets do, Mercury swings outward in a most eccentric way. In drawing its ellipse the two pins would have to be at least three inches apart. At one time Mercury is about twenty-nine million miles from the centre of the ellipse, and at another forty-three million miles. As it comes to the sharp curve when it is at its nearest to the Sun, it dashes round at the rate of thirty-five miles a second ; and well it may, since it is then exposed to a heat eleven times as great as the hottest we are accustomed to on Earth.

As Mercury always keeps the same face turned to the Sun it gets no relief from this terrific heat from cooling shades of night. The other side of the planet is not much better off since it is ever exposed to the darkness and cold of outer space. The temperature of Mercury ranges from something like 390° Centigrade above freezing point on the side turned toward the Sun, to 270° C. below on the side turned away from the Sun.

Rushing frantically to the opposite end of the curve it gradually attains a minimum speed of twenty-three miles a second. It is then said to be at *aphelion,* or the most remote point a planet can recede from the Sun without going beyond control into the outer dark, cold space. The word is derived from the Greek *apo,* away from, and *helios,* the Sun ; just as *perihelion* is derived from the Greek words *peri,* near, and *helios,* the Sun. It is well to

know the meaning of these words, for when you see in an almanac that a planet is at ' aphelion ' or ' perihelion,' it is as simple to understand as if you read that the planet is in London or New York.

I do not think I have told you that ' orbit,' the path along which a planet travels, is derived from the Latin word *orbis,* meaning a ring. In the year 1832, when a French astronomer announced that a comet, known as Biela's, after the name of its discoverer, would cross the orbit of the Earth, the ignorant and the superstitious were greatly alarmed. They were under the mistaken impression that the orbit was some part of the Earth, which might be affected in some way by the impact with the mysterious visitor from space. However, the astronomer reassured them by saying that the Earth would be millions of miles away from the *point* in its orbit which the comet would cross *when the Earth was not there.*

As a familiar illustration, we have often seen notices at a railway crossing warning us to look out for the train. Generally the gates are closed when a train is expected, and if we arrive in our car about that time, no amount of coaxing will induce the official in charge to open the gates for us. We are unable to follow the example of the boy who vaults over, or wriggles under, when the guard is not looking, so all we can do is to possess our souls in patience until the train has thundered by.

Now upon the celestial track there are no signboards to warn our planet of the stealthy approach of a comet, but even should it happen that the Earth and the comet met upon the track, a comet is made of such flimsy material that we should not suffer in the least. We actually had such an experience with a comet in the year 1861. Still less risk would there be when the comet is so small as the little fellow named ' Encke,' whose story, as we shall see later, is intimately connected with the story of Mercury.

Mercury takes eighty-eight days in completing its journey round the Sun, and in this short 'year' probably there are only two seasons, one when it is at its nearest to the Sun, and one when it is at its greatest distance. Imagine living on a planet where the Sun blazes in the skies with a disk four and a half times larger than that which we see from the Earth. This is when Mercury is at its greatest distance from the Sun, the disk increasing by more than one-half when the planet is at its nearest. It is not likely that there are any inhabitants on such a Mercury.

The planet is not only waterless and airless, but during the time when it is at its nearest to the Sun the heat is, as we have seen, eleven times greater than our own summer temperature. "Mercurian oceans would long ago have been boiled off from the one side," writes Miss Agnes Clerke in *Astronomy*, "and condensed into thick-ribbed ice on the other."

Mr Maunder in his book *Are the Planets Inhabited?* tells us:

> It is true that there is a 'debatable land,' for the face turned to the sun is not exactly the same at all times, and a region about 47° in width on each side of the planet, that is to say, rather more than a quarter of its entire surface, has one day and one night in each period of 88 days, but these more favoured sections can scarcely be considered more habitable than the rest.

Look at the Sun some evening when it is setting like a huge ball of fire in the western sky, and imagine it seven times larger; it is thus possible to gain some idea of sunset or sunrise as they would appear if seen from the "debatable land" Mr Maunder refers to.

Mercury is described as resembling a parched desert, its surface furrowed with deep cracks like those on the Moon. Moreover, it is possible that Mercury may have been a satellite of Venus that had at some remote period escaped from its control to dance attendance upon the Sun. According to Dr Crommelin of the Greenwich Observatory,

> Undoubtedly the tides raised by the Sun on Mercury have played a part in bringing about its rotation of 88 days, being the same as its year, but it would be a help to suppose that the rotation had first been slowed down by the action of Venus.

We now come to the final chapter in the story of Mercury, and if you would know it in detail it would be worth while going to the nearest library and borrowing Sir Robert Ball's *Starland*. I will, however, tell you the outline of the story, and this may encourage you to get the book.

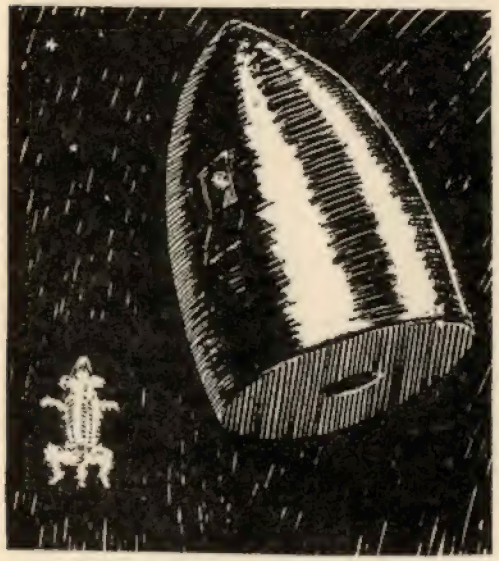
If a planet has a moon circling round it an astronomer can tell how heavy the planet is by calculating its pull on the little moon. We all know that it is the massive Earth which pulls us back when we jump into the air. If the Earth were smaller we should reach a greater height before we were pulled back. Sir Isaac Newton proved that the force which holds the Moon in her path round the Earth was the same as that which pulled objects to the ground. Were it not for this force, moving bodies would move on through space with the same speed for ever.

Every one knows the story of how Sir Isaac Newton, thinking out these great problems one afternoon, saw an apple fall from a tree. Now what was the force which drew the apple downward to the ground? This was the question Newton asked himself, but it took him twenty years to work out the answer and thoroughly establish his famous Law of Gravity. The weight of the apple is its downward pressure under the attracting force of gravity. This force is governed by the mass and the weight of each of the attracting bodies.

There is a piece of the actual tree from which Newton's apple fell at the Royal Astronomical Society's rooms in London. In Professor Turner's fascinating book, *A Voyage in Space*, there is an interesting account of how Newton discovered his wonderful law. Earlier in this book there is, also, a reference to Jules Verne's romance *From the Earth to the Moon*, in which the experience of

three adventurers are described. Two dogs, Diane and Satellite, accompanied the adventurers, and Jules Verne describes what Professor Turner tells us was perfectly impossible.

According to the story the terrific shock at starting was too much for Satellite, who died and was cast into outer space. In course of time "his body became flattened out like a bagpipe," as it ceaselessly circled round the projectile in which the adventurers travelled, like a satellite or moon. As a matter of fact, the pull of the Earth would have far exceeded the pull of the projectile, and Satellite would have fallen back on to the Earth. Moreover, as Professor Turner remarks, "when the trap-door was opened to put out the body of the poor dog, I fear all the air would have rushed out almost at once, and the men would have died too and so would the story."



THE UNFORTUNATE SATELLITE

We seem to have wandered a long way from Mercury, but the illustration seemed necessary if we wished to understand how a planet can be weighed when there is nothing to balance it with. When we take a packet to the Post Office, the assistant puts it on one of the scales and a weight on the other. When they are even, he tells you how much your packet weighs, and what you must pay. But in the

case of Mercury there was nothing to guide us, not even a wee, solitary moon.

However, a comet obligingly offered to tip the scales for us, and its name was Encke, after its discoverer. Sometimes comets are splendid visions, appearing with trains millions of miles in length, but Encke's comet was a faint little object, so that one has to search for it with a telescope. Now Encke is a regular visitor to the neighbourhood of the Sun, returning every three years at stated intervals. All the time it is tearing along at a tremendous speed, slackening when at its greatest distance from the Sun, but when at its nearest rushing along with a speed far greater than that of a cannon-ball. When the comet reaches the end of its journey outward it wheels round and returns by a different road, until it comes near enough to be seen. Astronomers scarcely have time to make it welcome when off it rushes again, until even the most powerful telescopes cannot keep it in sight.

Sir Robert Ball tells us about an astronomer and a mathematician who were great friends. The astronomer, who had been watching the comet, noting exactly where it was each night, told the mathematician all he had seen. The mathematician

> sits down at his desk, and begins to work long columns of figures until at length he discovers how to make a timetable which shall set forth the wanderings of Encke. He is able to verify the accuracy of his table in a very unmistakable way by venturing upon prophecies. The mathematician predicts to the astronomer the very day and the very hour at which the comet will reappear. He even indicates the very part of the heavens to which the telescope must be directed, in order to greet the wanderer on its return. When the time comes the astronomer finds that his friend has been a true prophet; there is the comet on the expected day, and in the expected constellation.

This happens again and again, but, to make a long story short, one day Encke failed to make its appearance at the scheduled time. We can imagine the

astronomer looking askance at the mathematician, and the mathematician clearing his throat, before explaining. His calculations were quite correct, they could not be otherwise. The comet was to blame, and it was asked to give an account of itself. Like all evil-doers it threw the blame for its delay on someone else, and that someone was no less than Mercury.

COMPARATIVE WEIGHT OF MERCURY AND THE EARTH

By permission of Messrs Cassell & Co., Ltd.

"I was," said Encke, "going quietly on my rounds as usual, when I had the misfortune to come very close to a little planet, of which I daresay you have heard—it is called Mercury. I did not want to interfere with Mercury; I was only anxious to hurry past and keep on my journey, but he was meddlesome and began to interfere with me, and I had a great deal of trouble to get free from him, but at last I did shake him off. I kept my pace as well as I could afterward, but I could not make up the lost time, and consequently I am here a little late. I know I am not just where I ought to be, nor am I now moving quite as you expect me to do; the fact

is, I have not yet quite recovered from the bad treatment I have received."

Then the astronomer and mathematician proceeded to test the story, and they found that it was true. The bigger and the heavier Mercury was, the greater would be his power of delaying the unfortunate little comet. By measuring how much it had been led astray, they could tell the force of the 'storm,' otherwise Mercury, which had caused the delay. After a very long and a very hard sum worked by the mathematician it was shown that Mercury must be a very light globe compared to the Earth. Sir Robert Ball, in his *Starland*, gives the neat little drawing which is reproduced here. It shows a pair of scales with the Earth in one balance and twenty-five little Mercuries in the other. However, since that book was written the mathematician has made a few more calculations, and we are now told that twenty-nine Mercuries would be required to make the balance even.

The time has now come to bid farewell to the rosy planet and we must turn our attention to its next-door neighbour Venus, hoping it may prove to be more comfortable as a possible future abiding place.

CHAPTER VI

VENUS, THE EVENING STAR

THE Greeks invented a beautiful legend about Venus, the name of the second planet in order from the Sun, and Shelley has woven it into a poem :

> Look, look, why shine
> Those floating bubbles with such light divine ?
> They break, and from their mist a lily form
> Rises from out the wave, in beauty warm.
> The wave is by the blue-veined feet scarce press'd,
> Her silky ringlets float about her breast,
> Veiling its fairy loveliness ; while her eye
> Is soft and deep as the blue heaven is high.
> The Beautiful is born ; and sea and earth
> May well revere the hour of that mysterious birth.

Like Mercury, the planet bears two names, Phosphorus, as the morning star, and Hesperus, as the evening star :

> Hesperus, that leads
> The starry host, rides brightest.

Venus, goddess of love and beauty, is also known by the name of Aphrodite, and her symbol is a looking-glass, represented by a circle and a cross-bar beneath to serve as handle.[1]

Venus is a queen among the planetary host, even outshining Jupiter, the prince of planets, and, at times, Sirius, usually the brightest star in the sky. When at her brightest the planet can be easily seen in broad daylight with the unaided eye. It is difficult to realize

[1] The symbol of Mercury is very similar; a crescent is added above the circle.

TYCHO BRAHÉ AND KEPLER

[See p. 77]

97

CRABTREE WATCHING THE TRANSIT OF VENUS
Ford Madox Brown
By permission of the Town Hall Committee of the Manchester Corporation
[*See p.* 101]

that all this splendour is simply borrowed sunlight, and that Venus is a dark globe like our own planet Earth.

A story is told of Napoleon when he was about to attend an afternoon reception in his honour at the Luxembourg. He could not understand why the people who had gathered to witness his arrival were staring up at the sky instead of at him and his suite. However, one of his courtiers explained that the people were looking with astonishment at a bright star supposed to be that of the Conqueror of Italy. The Emperor looked up and saw Venus shining down upon him in the middle of the day, and he appreciated the compliment.

Another story is told about an engine-driver in Virginia, whose train one evening was running through a strip of cypress forest. He was a little behind time, so, to quote his own words, " he was hustling his locomotive along at a pretty good clip." Just as he cleared the cypress forest the line took a sharp turn westward, and as he made it he was startled at seeing what appeared to be another engine coming down the track (it was a single-track line) from the opposite direction. Her headlight was flaming in his eyes.

Hurriedly he reversed his engine, and took his train back at full speed to a station about a mile behind him.

There he got on to a siding and waited for the other train to rush by ; but nothing happened. Then he wired up the line to see if there were any specials or wild engines in the way, but was told that the line was clear. The passengers, wondering what had happened, got out of the train and began to ask questions, but the engine-driver was too dazed to answer. He thought of run-away engines, train-wreckers, tramps, but everything was apparently quiet round the bend.

While standing on the platform wondering if it was safe to resume the journey he happened to glance west-ward across a clearing. There was the headlight shining as brightly as ever, but, as the man expressed it, " the

light was as serene and steady as you please." In a moment he realized that it was the planet Venus he had been dodging.

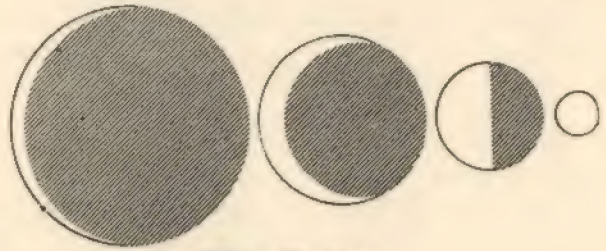
He instantly gave the signal that he was ready to go ahead, without a hint as to the cause of his alarm—"For," said he afterward, "if it had got around that I had side-tracked to let the evening star go by I'd never have heard the end of it."

During the year 1910, toward the end of May, when Halley's comet was attracting much attention in the western sky, a professor at an American observatory received a letter from a young lady who informed him that she had seen the comet as a very bright object due east in the morning sky, but "the poor thing had lost its tail." The object proved to be the planet Venus.

Venus is not to be seen at all times, and to those who are not acquainted with her movements she seems to come and go as she pleases. For months together the star of evening is hidden from mortal eyes. But every movement of the seemingly capricious planet is known to those who study their almanacs. Each step of the Queen of Beauty is given with prosaic detail as she moves along her path, but to those who do not pay much attention to astronomy there is undoubtedly a charm in the way she suddenly makes her appearance as the leading lady in the celestial drama.

It is a beautiful clear evening, the Sun has just set, and in the golden glory of the western sky a beauteous gem is seen to glitter. A few weeks later the Queen of Beauty has risen higher above the horizon and rides, an even more brilliant object in the sky, long after the shades of night have descended. She only occasionally attains her full splendour, but at such times she outrivals even Sirius more than twenty times. Then again she draws near the Sun and remains lost to view for many months, until she enters upon a new cycle of changes after an interval of a year and seven months.

There are two reasons why Venus attains such brilliancy. One is because being so near to the Earth she outshines even Jupiter and Saturn, which, although much larger planets, are at a greater distance not only from the Earth but also from the Sun, and consequently receive a smaller amount of sunlight. The other reason is that the surface of Venus reflects a larger proportion of the sunlight which illumines it. As the planets can only be seen by means of reflected sunlight, their



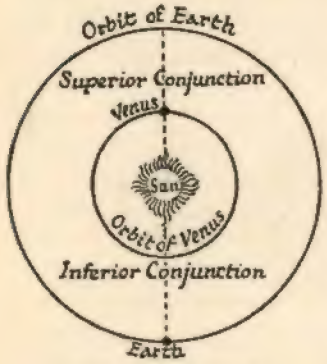
PHASES OF VENUS

brilliancy depends upon the amount of sunlight which they receive. Jupiter receives only one-twenty-fifth, and Saturn one-hundredth of the flood which falls upon the Earth; on the other hand, we receive only one-half the light which shines upon Venus.

Unfortunately we cannot see Venus at her best, because she is then between us and the Sun, and it is the face which is turned away from us which shines most brightly. Gradually as she circles round the Sun the planet shows phases like the Moon, appearing as a crescent, then like a Half Moon, resembling the Moon when it is four days old and appearing, when seen through a telescope, to be equal in size. As the planet moves to her position on the farther side of the Sun, or in superior conjunction, as this position is called, her appearance is similar to that of our Full Moon. Then the phases are reversed until once more Venus is hidden for a while from view.

The phases of Venus were discovered by Galileo in

1610, and helped to prove the truth of the Copernican system as opposed to the theories of Ptolemy. If at the time of what is called inferior conjunction—that is, when the planet is on the same side of the Sun as the Earth, with her sunlit side turned from us—the Earth, Sun, and Venus are directly in line, we are treated to a display known as the transit of Venus. A French artist has painted an allegorical picture showing the goddess Venus about to pass in front of the chariot of the Sun-god Phoebus, in memory of the transit which took place in 1874.



THE CONJUNCTIONS

The first eclipse ever observed was in 1639 and was noted only by two observers, Messrs Horrocks and Crabtree. It seems rather odd that two men should reserve such a great pleasure to themselves, but, wrote Horrocks, "I hope to be excused for not informing other of my friends of the expected phenomenon, but most of them care little for trifles of this kind, rather preferring their hawks and hounds."

Mr Horrocks, a young and ardent English astronomer, was also a clergyman. Unfortunately for his clerical duties, the transit of Venus was scheduled for a Sunday in midwinter, so that Mr Horrocks found it somewhat difficult to do justice to his church duties while, at the same time, he gave the necessary attention to the expected celestial display.

At nine o'clock he was due at church for the early morning service; as soon as this was over he hurried to his observatory to see what had happened during his absence, but Venus had not yet put in an appearance upon the brilliant face of the Sun. It is true there was a

Sunspot, but Mr Horrocks knew better than to be deceived into thinking that this was the expected planet. Then the time came for another service at the church; but he was back by one o'clock, and one can imagine that the sermon that day was severely clipped.

But the church was not the only impediment to his observations, for the Sun apparently objected to having a second place in the entertainment and sulked behind clouds during the greater part of the day. However, at a quarter-past three in the afternoon, when his clerical work was over, Mr Horrocks had the pleasure of seeing the Sun emerge from its temporary eclipse, and as the clouds dispersed he was enabled to resume his observations.

To his intense delight he then saw on the Sun the round dark spot which he at once identified as Venus.

But the short winter day was rapidly drawing to a close, and the Sun would soon set. Only half an hour was available, but Mr Horrocks had made such careful preparations that he was able to make some valuable measurements. During the last year of his life—his twenty-first—he also did some valuable work in connexion with Jupiter and Saturn, comets, and the tides. "Had he lived, what would he not have done?" asked Dr Wallis, who edited his papers.

A striking painting of Mr Crabtree's famous observation of this transit of Venus is to be seen on a wall of the Town Hall at Manchester. Should you visit that city you would do well to see the original, but for those at too great a distance our reproduction will be interesting.

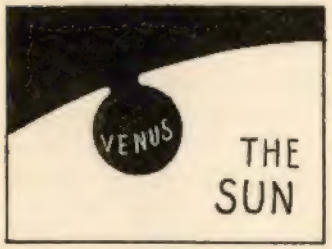
A later transit of Venus which occurred in 1769 is of great interest because it was the cause of the first of the celebrated voyages of Captain Cook.[1] It was to observe this transit that Captain Cook was commissioned to sail to Otaheite, in the South Seas, and there, on the 3rd of June, on a splendid day with clear, unclouded skies,

[1] See *The Book of Discovery*, p. 204.

observations and measurements were made by the astronomers of the expedition.

Gradually they saw the black spot steal in front of the Sun, until after nearly half an hour the whole of the black disk was visible. Slowly it wended its way, followed by hundreds of telescopes in many parts of the globe from which the transit was visible, until at length, in the course of a few hours, the planet emerged from the other side of the Sun.

Attempts were made to use the transits of Venus which occurred in 1874 and 1882 for obtaining a more accurate knowledge of the distance of the Sun from the Earth. Expeditions were sent far and wide at great expense, but alas! the observers were foiled by what is usually referred to as the 'Black Drop.' When this misfortune occurs Venus looks as though it is hanging on the edge of the Sun by a stalk, and the appearance is caused by the atmosphere surrounding the planet. It is then impossible to ascertain the exact moment when the planet touches or the exact moment when it leaves the disk of the Sun.



THE 'BLACK DROP'

As a result of this misfortune, present on both occasions, accurate observations could not be made, and the next transit of Venus will not occur until June 8th, 2004.

The expeditions in 1874 and 1882, as already remarked, were sent out to different parts of the world with the object of finding out how far the Earth is from the Sun. This distance has been sometimes referred to as 'the yardstick of the Universe,' and corresponds with the scale of miles printed on our maps. Without such a scale the map would have little practical value. The story of a gentleman who was planning a trip round the

world suggests the need for a standard of comparison. Looking at the space between Australia and New Zealand on a small map, he remarked to a tourist agent: "I suppose that can be crossed in a day?" He was very much surprised to learn that the journey would occupy at least a week.

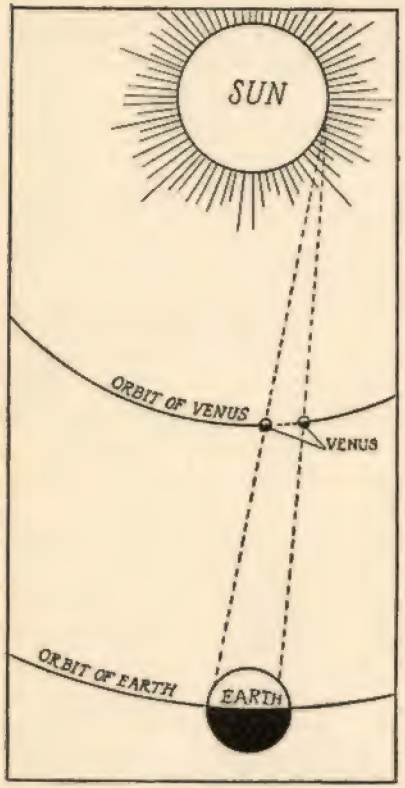
I can imagine some of my young readers wondering why it is so important to know how far away the Sun is that expensive expeditions are sent long distances to observe the transit of Venus. Well, every ship that comes in or goes out of a harbour depends upon the *Nautical Almanac*, and that wonderful guide for the mariner depends upon our accurate knowledge of that distance. Seamen tell us that in running for a harbour on a stormy night even a yard of sea-room more or less may often be of great consequence, so it may happen that a gallant vessel may owe its safety to the influence of the transit of Venus on the *Nautical Almanac*. But how is the problem solved?

Do you know why you have been provided with two eyes? It is generally said that one of the reasons is to help you in estimating distances. Hold up a ruler in front of you at arm's length and look at it with your left eye, keeping your right eye closed. You will see the ruler, let us suppose, outlined against a picture on the wall. Now open your right eye, and close your left eye. The ruler appears to be in a different place, and this is due to the difference in the position of the eye looking at the ruler.

When measuring the distance of the Sun from the Earth a triangle is formed of which the base is a line between two observatories stationed a considerable known distance apart, and the apex is the Sun. The two eyes in our example are represented by the observatories, and the ruler is Venus as it passes on its course between the Earth and the Sun.

The sides of the triangle are the lines from the

observatories to the Sun, and on both sides of the world astronomers note the moment when they see Venus cross their lines, some distance below the apex. The difference in the time of the planet's appearance on the two lines is carefully recorded, and this provides a key which by means of mathematics solves the problem.



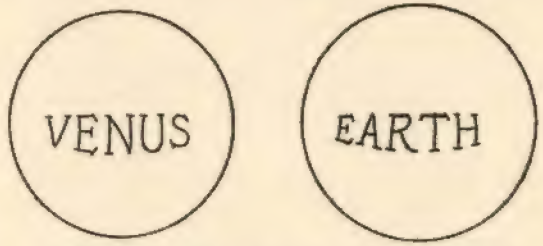
MEASURING THE DISTANCE TO THE SUN

Knowing that the Sun is nearly 93,000,000 miles away from the Earth helps us to make a map of the solar system to scale. For instance, let us use our 'yard-stick' to give us the distance of the outermost planet, Neptune, the sentry in the solar system who keeps the planets from wandering 'out of bounds.' We find that we have to put it down thirty times end over end before we reach our goal. Do you realize what that means? You will get an idea of it from the following illustration in *The Star World* by Dr Crommelin :

> Even within the planetary system we meet with distances that are beyond our powers of conception. Thus, the most distant planet, Neptune, is thirty times as far from the Sun as the Earth is, or 2,800 million miles. The greatest travelling speed that man has at present attained is 144 miles per hour in an aeroplane. About 2,300 years of continuous travelling at this rate would be required to reach Neptune (say, from the time of the Babylonian

> Captivity to the present day). The depth of the abyss that separates us from the nearest fixed star is nine thousand times the distance of Neptune, so that travelling at the speed of the fastest aeroplane, we should require 22 million years to cross it.[1]

Venus is a world just like our planet, but she certainly cannot be inhabited. The great French astronomer



COMPARATIVE SIZE OF VENUS AND THE EARTH

Flammarion, in a book written over forty years ago, drew a fanciful word-picture of Venus which, like our globe, is

> surrounded by a transparent atmosphere in the midst of which are combined thousands of shades of light. Clouds rise from the stormy ocean, and transport into the sky snowy, silvery, golden and purple tints. At morning and evening when the dazzling orb of day, twice as large as it appears from the earth, lifts its enormous disk at the east or inclines towards the west, the twilight unfolds its splendours and charms.

This is very pleasant to contemplate, but, like Mercury, the planet always keeps the same face turned to the Sun, so that scorching heat must prevail in the regions where the Sun never sets, and bitter cold in the regions where it never rises. The young lady whom Flammarion praises because she promised "swiftly to soar to Venus when her imprisoned soul was free," would doubtless have changed her mind and wished she had taken a return ticket when she found the dreary fate

[1] It has to be noted that since Dr Crommelin wrote the speed of the aeroplane has considerably increased.

awaiting her. For, as far as we can make out, the planet is enshrouded by such a dense canopy of clouds that the Sun and stars are rarely, if ever, seen. Venus has no attendant moon, and the Earth with its companion Moon, seen through occasional rifts in the clouds, would prove an alluring spectacle to inhabitants of Venus, could such exist. Moreover, they would be able to see the side of the Moon which has never favoured us with a view.

Tennyson in "Locksley Hall Sixty Years After," brought the vision of a poet to the theories of astronomy:

> Hesper—Venus—were we native to that splendour or in Mars,
> We should see the Globe we groan in, fairest of their evening stars.
>
> Could we dream of wars and carnage, craft and madness, lust and spite,
> Roaring London, raving Paris, in that point of peaceful light?
>
> Might we not in glancing heavenward on a star so silver-fair,
> Yearn, and clasp the hands and murmur, "Would to God that we were there"?

CHAPTER VII

MARS, THE PLANET OF ROMANCE

> And the first watch of night is given
> To the red planet Mars.
>
> LONGFELLOW

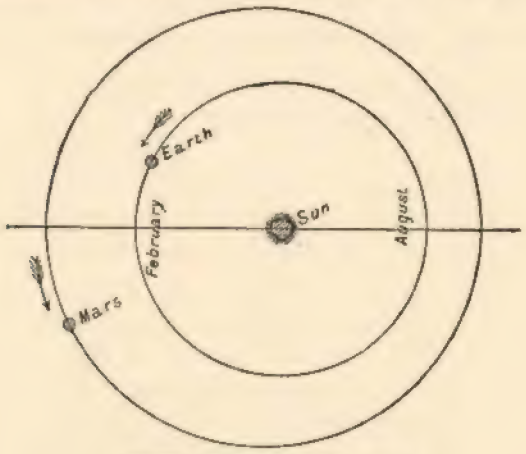
THE planet Mars, "the ancient warrior's star," was named after the god of war, by the Greeks, doubtless because of its ruddy hue. Its symbol, a shield and a spear, is represented by a circle surmounted by an arrow tilted to the right. There are times when this brilliant orange-red star is seen in the opposite part of the sky to the Sun, rising at sunset and reaching its highest in the sky at midnight. The planet is then said to be in opposition, which condition arrives when the Earth is between it and the Sun.

It has often been asked: "Is Mars inhabited?" or, "Can we signal to the inhabitants of Mars?" Several years ago a Madame Guzman offered a large sum of money to the first person who succeeded in conversing, by means of signals, with an inhabitant of Mars, and the promised amount is still in the safe keeping of the French Academy of Science, where it will doubtless remain.

Endless plans for signalling to Mars have been suggested from time to time. For example, by such means as geometrical figures outlined with electric lights upon the desert, or a series of mirrors reflecting the Sun's light over an area of one-quarter million square feet. Even the noted electrician Tesla joined the enthusiasts, wireless in his opinion being the method most likely to attract the attention of Martians, if any there be.

In these days when boys and girls have become such

adepts not only in the use but even in the construction of wireless sets, the following suggestion made by Tesla in an article written by him for the *New York Times* in 1909 may be of interest. A few years ago this would have been considered far too technical for a book such as this,



ORBITS OF EARTH AND MARS
From "In Starry Realms," by Sir Robert Ball

but nowadays boys and girls are running so far ahead in their knowledge of the make-up of wireless that it has been whispered that their elders will have to look out for their laurels. With this in mind I have no hesitation in quoting Tesla's suggestion of the means by which it might be possible to send a wireless greeting to the inhabitants (if any exist) on Mars.

> A circuit properly designed and arranged is connected with one of its ends to an insulated terminal at some height and with the other in the earth. Inductively linked with it is another circuit in which electrical oscillations of great intensity are set up by means now familiar to electricians. This combination of apparatus is known as my wireless transmitter.
>
> By careful attunement of the circuits the expert can produce a vibration of extraordinary power, but when certain artifices are resorted to, the oscillation reaches transcending intensity. By

> this means, I have passed a powerful current around the globe and attained activities of many millions of horse-power. Assuming only a rate of 15,000,000 readily obtainable, it is 6,000 times more than that producible by mirrors.
>
> But my method has other and still greater advantages. By its employment the electrician on Mars, instead of utilizing the energy received by a few thousand square feet in area, as in a parabolic reflector, is enabled to concentrate in his instrument the energy received by dozens of square miles, thus multiplying the effect many thousands of times. Nor is this all. By proper methods and devices he can magnify the received effect as many times again.
>
> It is evident that in my experiments in 1899 and 1900 I have already produced disturbances on Mars, incomparably more powerful than could be obtained by any high reflectors however large. Electrical science is now so far advanced that our ability of flashing a signal to a planet is experimentally demonstrated. The question is: When will humanity witness that great triumph? This is easily answered. The moment we obtain absolute evidence that an intelligent effort is being made on some other world to this effect interplanetary transmission of intelligence can be considered as an accomplished fact. A primitive understanding can be reached quickly without difficulty. A complete exchange of ideas is a greater problem, but susceptible of solution.
>
> (Signed) NIKOLA TESLA

However, there seems as much probability of establishing communication with the Martians as there is in construing a message out of the spider-like webs which, at certain seasons of the year, cover the greater part of the planet's surface like a net.

These lines—the so-called canals of Mars—were first detected in 1877 by the keen eyes of the Milanese astronomer Schiaparelli.[1] They were called by him *canali*, though he had in mind channels, such as the English Channel. My father had made a nice little map of Mars from a series of drawings by the 'eagle-eyed' Dawes which were charted in 1852–64. Mr Dawes, an amateur astronomer keenly interested in the study of Mars, drew what he saw very carefully, and when these

[1] Pronounced *Skee-a-pa-relli*.

drawings were put together, the chart showed that there were divisions of land and water, just as such divisions would appear on our planet if seen by an inhabitant of Mars. The geography of Mars is called 'Areography,' after Ares, another name for Mars.

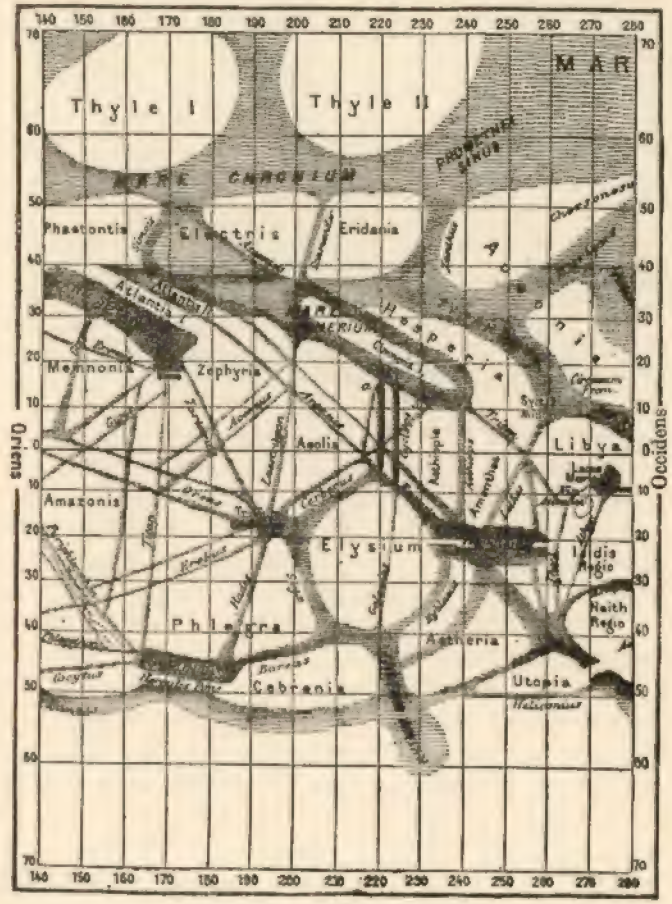
On this map there are polar caps surrounded by polar

CANALS ON MARS
From "In the High Heavens," by Sir Robert Ball

seas, and there are four continents named after four observers, Dawes, Madler, Secchi, and Herschel. The Herschel continent is separated from Secchi continent by Huggins Inlet and two northern seas, one named Tycho, after Tycho Brahé, and another after Airy, one time English Astronomer Royal.

A careful study of the map shows an even division of land and water on the surface of the planet, so that a traveller could visit almost every part by land if he wished to do so by motor-car, or every part by yacht

if he preferred a journey by water. Provided with this map a visitor to Mars would be able to find his way about



PART OF A MAP OF MARS
From "In the High Heavens," by Sir Robert Ball

with ease, but later discoveries have proved that a surface thought at first to be land is part water. Next the land was seen to be seamed with straits (the so-called 'canals');

finally the seas were found to be land, and the water-supply extremely limited.

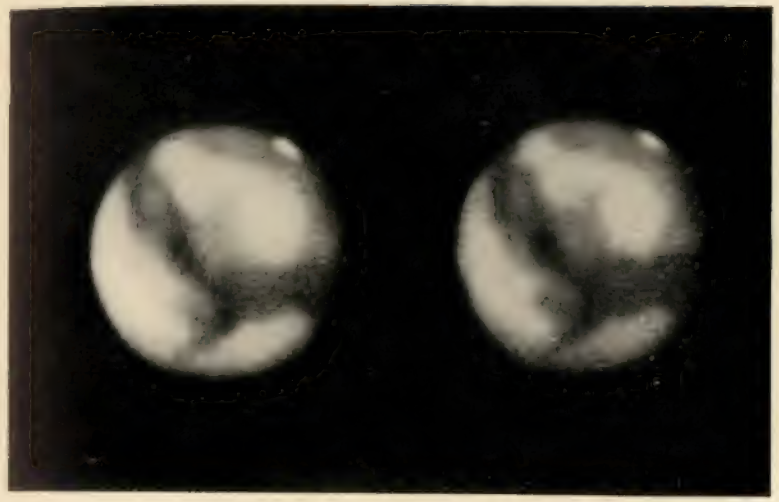
Consequently this convenient chart has been replaced by a map containing the markings observed by Schiaparelli, with names taken mostly from ancient geography. Thus we find Elysium, Hesperia, Triton, Plutus, Acheron, Arcadia ; the Hour-glass Sea has become Syrtis Major, and the Lake of the Sun—the terminus of many canals, where we can imagine Martian merchants most do congregate—is now known as Solis Lacus.

For nine years Schiaparelli was the only observer who could detect the channels, and when he announced that the mysterious lines had doubled, defective eyesight was suspected. His discoveries were so amazing that rival observers denounced them strongly.

In the first map, the 'canals' were shown as narrow, winding streaks. In 1879 the lines appeared straighter, narrower, and as if planned by careful measurement. In 1881–82 they had become as straight as any draughtsman could wish, and this regularity they have retained. Moreover, in 1892 W. H. Pickering at Arequipa saw small round spots scattered over the surface of the planet. These were called oases, and their average size is fifty to seventy-five miles.

The next step in exploration of the planet was made by Professor Lowell. In 1894 he found canals in place of the irregular streaks and river-systems observed by Schiaparelli, and that the so-called seas were seamed by lines as regular as the canals already observed in the land regions. Photographs were taken of Mars in 1907 and 1909, and on each the canals were visible. Professor Lowell remarks :

> When I say canals, I do not mean ditches dug on the planet. What I contend is that the planet bears upon it markings which are evidence that there is intelligent life of some sort upon it, but not necessarily human life. It is perfectly clear, however, that these lines or canals are strips of vegetation.



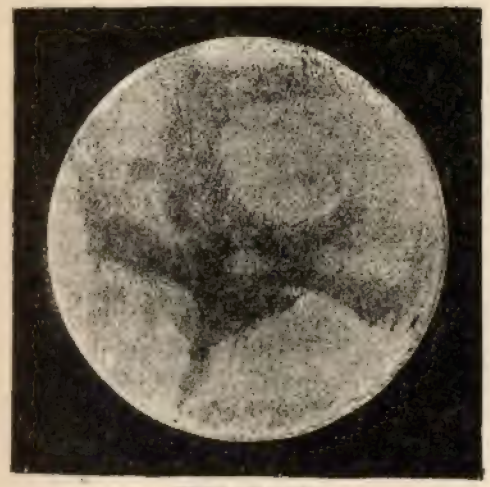
PHOTOGRAPHS OF MARS 112

Taken at Mount Wilson Observatory with the 60-inch reflector

JUPITER'S SATELLITES VI, VII, AND VIII
Photographed at Greenwich Observatory
The inset is a photograph of Jupiter taken at the Lowell Observatory, Flagstaff, Arizona. *(By permission of Mrs Lowell)*
[*See p. 130*]

Mars, the Planet of Romance

His theory is that the canals are not visible during the winter season, but when the snow and ice begin to melt at the polar regions an immense quantity of water is set free. This is carried through canals made for the purpose to every part of the planet. As the amount of water on the surface of the planet is extremely limited, an irrigation scheme such as this must be of the utmost value. The double lines we see do not represent double canals, but vegetation on each side of large canals such as is to be seen in spring along the banks of the Nile.



VIEW OF MARS
From "In Starry Realms," by Sir Robert Ball

Step by step our knowledge of the planet has increased, from the days of Galileo, who in 1610 observed it for the first time through his magic glass, up to the present, when the search is being carried on by means not only of giant telescopes, but with the attached photographic camera, which reveals minuter details of the planet's surface. From time immemorial travel and discovery have beckoned to men to leave the comforts of home and to brave danger in search of new lands and further knowledge, whether in far Arctic regions or upon the lofty peaks of Mount Everest. It was this same call, across the vast ocean of space, which inspired Professor Lowell to explore the realms of distant Mars, for which purpose he planned the erection of his famous Observatory at Flagstaff, Arizona.

When about to visit this Observatory a few years ago

I heard a fellow-passenger remark, as we were leaving the train at Flagstaff station, " This is the only place on earth where astronomers have been able to signal Mars ! "

To reach the Observatory our train passed along the Santa Fé trail, familiar to readers of romances of the Border Days when these desolate regions were the haunts of the Cheyenne, Kiowa, and Comanche Indians. Their memory is recalled along the Valley of Death by the wrecks of camps and waggons. The only sound that now disturbs the stillness of the night is an occasional long-drawn, unearthly howl marking the prowling presence of a stray coyote. Gone, as it came, the sound dies away in the distance, and the stealthy intruder is lost amid the gloom of the pines.

The Observatory stands upon a clearing in an extensive pine forest that covers the plateau and mountains nearly to their tops. It is situated nearly two thousand miles from Chicago, and at an altitude of about seven thousand feet above sea-level. To be a mile and a half nearer the stars means clear skies, and an unrivalled view of the planet of romance. Each night the observer returns to the telescope, sets the circles, and, punctual to the second, the planet swings into the field of view.

There glows the ruddy orb, only a little more than half the size of the Earth—its diameter being about 4,200 miles and that of the Earth about 7,920. The mass of Mars, calculated from the motions of its moons—of which more later—is about one-ninth that of the Earth. Consequently, the force of gravity at its surface is only about one-third of that experienced here. A weight of nine stone on Earth would, if weighed on Mars, only register three stone. Therefore, a man who weighs twelve stone here, would weigh but four stone on Mars. An athlete who could jump five feet here could on Mars jump thirteen feet with the greatest ease, and a Martian elephant might gambol as gracefully as a terrestrial deer. In these conditions engineering operations on Mars would

be much easier for beings with the strength of earthly men.

Is it possible that there can be life on Mars—men and women like those on Earth ? We know from the size of the planet that its atmosphere must be one half the density of that prevailing on the top of our highest mountains. The mean distance of Mars from the Sun is a little more than one and a half times that of the Earth (141,500,000 miles), so that it must have a mean temperature close to that of freezing mercury. Mr Maunder, summing up the facts in his book *Are the Planets Inhabited ?* writes :

> What chance would there be for life on a world the average condition of which would correspond to that of a terrestrial mountain top, ten miles high, and in the heart of the polar region ?

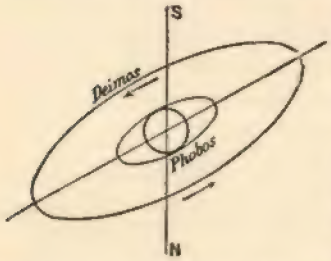
The drying up of the planet will proceed slowly until it will become a dead world like the Moon, rolling in its ceaseless journey round the Sun, a definite answer to the query, " Is Mars inhabited ? "

Mars is provided with two moons ; these were jokingly predicted by Dean Swift, in *Gulliver's Travels*, when he described the astronomers of Laputa discovering " two lesser stars as satellites which revolve about Mars." He even came very near the facts with regard to their size and distance from the planet.

The actual discovery was not made until 1877, when the moons were first seen by Professor Asaph Hall while observing the planet with the great telescope at the Washington Observatory. The American astronomers proposed to name the moons Romulus and Remus, but accepted a suggestion made by Mr Madan, a master at Eton, who thought it would be better to call them Deimos and Phobos (Dread and Terror), after two sons of the god of war.

Both moons are very small, the larger, Phobos, having a diameter of less than forty miles, and the smaller of

only eight or ten. The inner moon, Phobos, is about 5,800 miles from the centre of Mars, while Deimos is distant 14,600 miles. Phobos revolves round Mars in one-third of a Martian day; were there an observer on Mars it would appear to him to rise in the west and set in the east after an interval of 5½ hours, since its rate of rotation is so much more rapid than that of Mars on its axis. It pursues, in fact, the shortest path in the solar system. Deimos, on the contrary, revolves round Mars in a period of thirty hours eighteen minutes, remaining above the horizon for nearly three days without setting, and during that time it goes twice through all its phases (from new to full moon).



ORBITS OF THE MOONS OF MARS
From "In the High Heavens," by Sir Robert Ball

Assuming that the substance of the moons of Mars is not so closely packed together as on our planet, then the attraction of gravity at the surface of one of these moons will probably be about one-six-hundredth part of our familiar terrestrial gravity. Some queer results should arise in consequence. The slow-motion pictures shown at the cinema will give an idea of the movements of a man jumping upward on a Martian moon. He would ascend to the height, we will say, of half a mile, and his ascent and descent would occupy five minutes.

In his book *Poetry of Astronomy* my father wrote concerning these moons:

> Since the attraction on one of these moons will be less than the attraction at our Moon's surface, in the same degree that the diameter of a Martian moon falls short of our Moon's diameter, it follows that . . . if a man weighing 10 st. 10 lbs. (or 150 lbs.) were placed on one of these moons, he would weigh only a quarter of a pound, so that he could be forwarded by book-post for a penny, assuming size to be no objection. But a world admitting such vagaries is not a reasonable or probable world.

As givers of moonlight to an observer on Mars the moons would be of little value. Deimos gives only one-twelve-hundredth part of the light given by our full Moon, while Phobos gives but one-sixtieth part; as seen from the Earth the satellites of Mars appear no brighter

MARS AND ONE OF ITS MOONS
From "In the High Heavens," by Sir Robert Ball

than would an ivory globe seven inches in diameter if observed glistening in the sunlight at a distance of one hundred miles.

But we must now bid farewell to the planet of romance and its satellites, and find new wonders to describe in the planetary kindergarten which revolves between Mars and the giant Jupiter.

CHAPTER VIII

THE STORY OF THE ASTEROIDS

BETWEEN Mars and the giant planet Jupiter there is a great gap of over three hundred million miles. For a long time it was strongly suspected that a missing planet occupied a place within this gap, but the truth was not discovered until January 1st, 1801. The story well illustrates what can be accomplished by persistent and tireless effort.

Our story begins with an organized search planned under the leadership of Baron Von Zach at Lilienthal, in Germany, when twenty-four observers agreed to take part " in tracking and intercepting the fugitive subject of the Sun." They divided the great circle called the ecliptic, along which the Sun appears to travel annually among the stars, into twenty-four sections. Like every great circle, it contains 360°, and it is divided into twelve equal arcs of 30° each, called the signs of the Zodiac, which the ancients distinguished by particular names :

The Ram, the Bull, the Heavenly Twins,
And next the Crab the Lion shines,
The Virgin and the Scales ;
The Scorpion, Archer, and Sea Goat,
The Man that holds the watering-pot,
And Fish with glittering scales.

The twelve signs were divided among the twenty-four astronomers, each couple taking one particular sign under their care. They made a note of all stars visible within eight degrees on either side of the ecliptic, the broad highway along which the planets travel. Their task was not an easy one as stars and planets are apt to look

much alike. In fact, the planet for which they were in search was so cleverly disguised as a star that it had escaped detection for centuries. However, there was one

THE SIGNS OF THE ZODIAC

certain way of tracking the truant, and the twenty-four astronomers made their plans accordingly.

They knew that the stars are so far away that if we watched them for a hundred years they would seem motionless, but planets are comparatively near, and can be followed as they move against the background of various groups of stars in their journey round the Sun.

They resemble the leaf-like insects which remain absolutely motionless on the stem of the plant they imitate at the approach of danger, for example, a bird in search of food for its hungry nestlings. Now a wise bird is not easily deceived; it waits patiently, keeping meanwhile a wary eye on a suspected leaf. Presently the 'leaf' moves, and instantly mother bird pounces on it and conveys it in triumph to her family.

Now the asteroids, from the Greek *astron*, star, *eidos*, form (so named because they are starlike), can be easily mistaken for stars, but an observer who watches them carefully night after night finally sees one creeping along among the stars and captures it as a planet or wanderer. At once it is given a number, encircled in a ring, and later on, when its identity is established fully, it receives a name. A glance at the list shows that when the names of mythological deities became exhausted such homely names as Vera, Helena, Rachel, Angelina, Julia, Edith, and Marion were drawn upon. Chicago, Austria, Hungaria, also find a place, together with distinguished people, like Carnegie, who has a little planet of his own under the name of Carnegia.

Naturally the discovery of No. 1 was the most important, and, as often happens, while the twenty-four astronomers were giving their whole and undivided attention to the search for it, it was found by some one else.

For ten years a Sicilian astronomer, named Piazzi, had been making a chart of all the stars he could see in the ecliptic region where the combined search was being made, when on January 1st, 1801, to his surprise, he found a little starlike object which the next evening had changed its place in the group. In a few evenings Piazzi was convinced that it was slowly but surely moving, and he concluded at first that it must be a comet without a tail. It did not occur to him that it might be the missing planet.

He wrote to some friends in Milan and Berlin, telling them to be on the look-out for the supposed comet, but

unfortunately mails were slow in those days, and owing to delay in its delivery the friends of Piazzi did not receive his message until several weeks later. Meanwhile, two events occurred which nearly resulted in the loss of the newly discovered planet. First, owing to a severe illness, Piazzi had been compelled to suspend his observations of the supposed comet, and secondly, the moving object had come in line with the Sun, so that it was invisible in the glare of sunlight.

Meanwhile, an astronomer named Bode suggested that the moving object seen by Piazzi might be the missing planet, and advised the twenty-four astronomers to watch for it as it emerged from the overpowering glare of the Sun's light. Undoubtedly the planet would try and evade capture, but a mathematician named Gauss promptly came to the aid of the seekers.

As we have already seen in our talk about Mercury, these mathematicians are very wonderful people. Without even a glance at the sky Gauss was able by means of a series of calculations to say where the missing object was likely to be found. He argued that since it was seen by Piazzi in a certain part of the sky on January 1st, 1801, it would probably make its reappearance about the same time and near the same place a year later.

The astronomers, therefore, were told to set their traps for the wanderer on a certain date, but, as so often happens at such times, the eventful night proved to be misty, and sleet, rain, and clouds hid the truant from view. A gloom as deep as that which covered the heavens settled over the astronomers, and they bemoaned their ill-luck. However, on the last night of the year Baron Von Zach, who was stationed at Gotha, rediscovered the asteroid almost exactly in the part of the heavens predicted by Gauss, and it has remained permanently a captive ever since. Next evening it was seen again, and this time by Dr Olbers, exactly a year from the time of its discovery. Piazzi named the new planet

Ceres Ferdinandea, after the goddess supposed to preside over Sicily and in honour of the King of Naples, but it is generally referred to as Ceres.

The astronomers now supposed that their search was at an end, but it was soon evident that their work was only just beginning. About two months after the rediscovery of Ceres a second asteroid was found by Dr Olbers, who named it Pallas. As both planets were so extremely small (Ceres not exceeding a diameter of 485 miles, and Pallas 304), Dr Olbers suggested that perhaps the original planet had exploded, Ceres and Pallas being fragments, and that it might be as well to look for other such fragments. The explosion theory was apparently confirmed, two more asteroids being found during the next two years; these were named Juno and Vesta.

COMPARATIVE SIZE OF THE ASTEROIDS AND THE BRITISH ISLES

After continuing the search during the next nine years without further success, Dr Olbers decided to rest on his laurels. In consequence, no more asteroids were discovered until the year 1845. Then the untiring energy of a retired postmaster named Hencke, who devoted fifteen years of his life to a search for possible stray asteroids, was rewarded when he found one, which he named Astræa, and another, eighteen months later, which he called Hebe. Further discoveries followed, especially during recent years by the aid of photography, until the number of known asteroids now

runs to a thousand. The story is told of an astronomer who suggested that the asteroids were becoming so numerous that it might be as well to lose a few. But although some of these planets are so small that they are but "boulders broke loose," nevertheless even such fragments may serve a useful purpose.

For instance, the minute orb Eros, which was discovered in 1898 by Dr Gustav Witt, at the Urania Observatory, Berlin, occupies a most important place among the asteroids. This is due neither to its appearance nor size, for it is but twenty miles in diameter. Eros is notable because it is venturesome, coming nearer to the Earth than any other heavenly object, excepting an occasional comet. It approaches at times within fourteen million miles, providing us with an excellent opportunity for obtaining a better estimate of the distance of the Sun from the Earth than would otherwise be possible. Because of the length of its trail on the photographic plate, Eros was at first mistaken for a comet. However, when Dr Witt turned the great telescope of the Observatory toward this celestial object, he could not doubt its nature. Eros would surely be puffed up to a monstrous size by vanity were it aware that every available telescope and camera will be trained in its direction when it draws near to our planet in 1931.

Many of the asteroids are so small that their combined bulk is but one-twentieth of that of the Moon. An eminent astronomer once remarked during a lecture given at a boys' school that should boys play football on one of these little worlds they would have to be extremely careful. A powerful kick might send the ball off the planet to circulate round the Sun as a little planet on its own account.

There are certain groups of asteroids, such as the Hilda Group, comprising Hilda, Ismene, Chicago, Bononia, Venusia, and Simeisa, and the Trojan Group, which includes Achilles, Hector, Nestor, Agamemnon, Patroclus,

and Priamus. There are five other family parties which together form nearly a seventh of the known asteroids. They have been named as follows—the number of members of the family is given after the name: Themis, twenty-five members; Eos, twenty-three; Caronis, fifteen; Maria, thirteen; and Flora, fifty-seven. It would seem as though these are the fragments of not one planet, but several which exploded in the days of long ago.

The wonder is that these little worlds are not constantly bumping against each other, but their paths are so nicely arranged that were these silver hoops it would be possible to lift out one without disturbing others. The two most venturesome asteroids are Eros, already referred to, and one, known only by a number, 944, which strikes out beyond the path of Mars, almost to that of Saturn, crossing the path of Jupiter on the way. Fortunately its path is tilted so that it soars high over Jupiter, otherwise there is no knowing what might happen to it, as Jupiter is not above taking into his train any stray moons and comets which he can annex.

This venturesome asteroid requires thirteen years to complete its 'annual' journey round the Sun; an appropriate name for it would be 'Ventura.'

Sometimes when planets are lost a reward is offered for their recovery, as in the case of Bruccia, named after Miss Bruce, an American lady who was generous in aiding by gifts of money astronomical research. A family of twenty-five asteroids discovered by Professor Watson was endowed with a certain sum of money, to be devoted to their observation after his death. Æthra, which he discovered in 1873, was lost and not found again until December 1922—some fifty years later.

We know hardly anything of the nature of these small worlds, but if life exists on them it must be in a totally different form from anything on Earth. The extraordinary lightness of all matter would make flying easy.

Human beings would weigh only a few pounds, and with a pair of wings we could soar to heights far greater than an airman could attain on Earth.

In *Starland* Sir Robert Ball remarks:

> Life on these planets would be indeed unusual. Let us take, for example, the asteroid Flora, and see how a game of lawn tennis on that little world could be managed. The very lightest blow of the racket would drive the ball a prodigious distance before it could touch the ground; indeed, unless the courts were about half a mile long, it would be impossible to serve any ball that was not a fault. Nor is there any great exertion necessary for playing lawn tennis on Flora, even though the courts are several hundred acres in extent. As a young lady ran to meet the ball and return it, each of her steps might cover a hundred yards or so with perfect grace; and should she have the misfortune to get a fall, her descent to the ground would be as gentle as if she were seeking repose on a bed of the softest swansdown.

A body weighing fourteen stone on the Earth would weigh less than five ounces on the asteroid named Menippe. "A person might there leap to a height of several hundred feet, in which case he would not return in much less than an hour. Of such speculations," says Sir John Herschel, "there is no end."

CHAPTER IX

JUPITER, THE PRINCE OF PLANETS

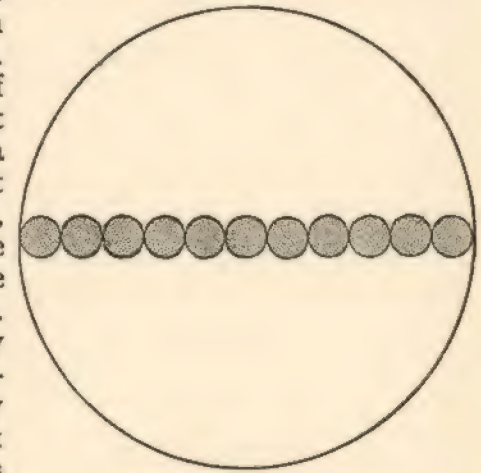
IN the days of old when the ancients believed that the planets were gods, they named the brightest of all these heavenly bodies after Jupiter, the King of the gods. His symbol was a sign which means 'the bird of Jove,' and by this sign the planet is shown in almanacs and calendars. In Asia Minor and Greece splendid temples were erected in honour of the god, the ruins of which remain to this day, and his abode was said to be on the summit of Mount Olympus, in Thessaly.

A gate of clouds in care of goddesses named 'the Seasons' opened when the Celestials visited the Earth, and within the gates the gods had their separate dwellings. Jupiter lived in a magnificent palace, and within its halls the King of the gods feasted on ambrosia and nectar. The sky was supposed to rest on the top of Mount Olympus, and when it was darkened with clouds and thunder and lightning, alarming the people on Earth, men believed that Jupiter was angry and might hurl thunderbolts at mortals who had offended him. For instance, Phaeton, an unruly son of Apollo, attempted to drive the chariot of the Sun, and Jupiter struck him to Earth with a thunderbolt. When the King of the gods was pleased, as we shall see later (in legends of the stars), he placed more fortunate mortals among the stars.

These fairy-tales of the heavens told by people of olden times are now replaced by facts which are far more wonderful than any of the Greek myths. Jupiter may well be termed the Prince of planets, even though the god has been deposed from his throne on Olympus. This

vast orb exceeds in size and weight all the other planets rolled into one. If it were represented by a football, the Earth in proportion would not be larger than a marble. Could it be weighed in a mighty balance, three hundred and sixteen globes as massive as the Earth would be required to make the scales even. The bulk of Jupiter exceeds that of the Earth more than thirteen hundred times.

The diameter of Jupiter is eighty-eight thousand miles, so if a tunnel could be cut through the centre, eleven globes the size of the Earth could be placed in it side by side.

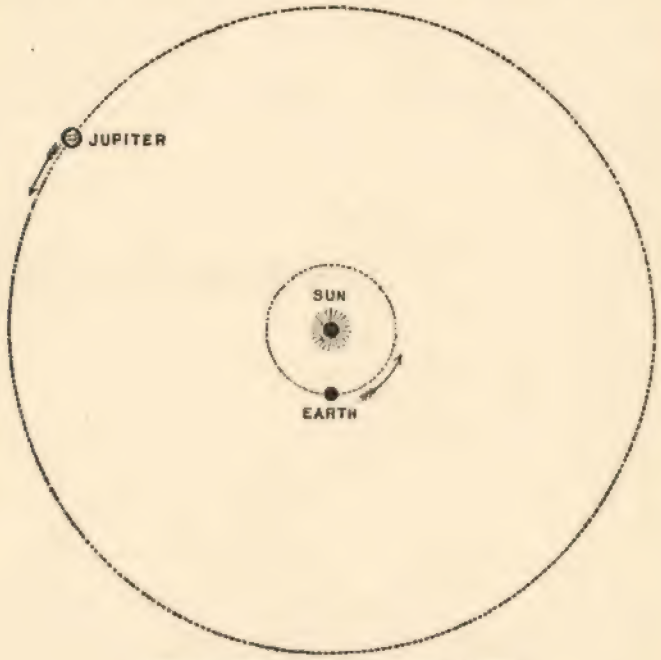


DIAMETER OF JUPITER
It is eleven times that of the Earth.

Jupiter takes nearly twelve years to complete its annual journey round the Sun, so that a boy or girl who is twelve years old here would be but one year old on Jupiter. He or she would only arrive at his or her twelfth birthday after one hundred and forty-four years had elapsed on Earth. The reason Jupiter requires so much time for its journey is not only because of the immense circuit which it makes, being distant from the Sun five times as far as is the Earth, but because it travels more slowly, as the Sun's pull on it is not so strong at that distance. While the Earth is whizzing through space at the rate of about nineteen miles a second, or seventy-five times the speed of an ordinary cannon-ball, Jupiter is ambling at the rate of only eight miles a second.

The day on Jupiter is much shorter than ours, lasting

less than ten hours, so that if we lived on that planet and rested for five hours there would remain only five hours in which to study, play, eat, and do our shopping. But from what the telescope tells us we cannot imagine Jupiter as a very desirable dwelling-place. To begin



ORBITS OF JUPITER AND THE EARTH

From "In Starry Realms," by Sir Robert Ball

with, it is always surrounded by dense masses of cloud, so that it is impossible to say what the surface of the planet is like. However, through occasional rifts in the clouds we are able to obtain a glimpse, and we receive the impression that the vast globe is intensely hot, the surface glowing like molten iron. Astronomers are not agreed about this, however, and some hold that the planet may be cold, which is quite likely. It is so far

away from the Sun that it only receives one twenty-seventh the amount of heat cast upon the Earth. But in either case Jupiter would not be a comfortable world; if it is hot, we might as well try and live in a furnace, like a salamander; if it be cold, we should be frozen stiff. Moreover, on a planet as massive as Jupiter our weight would be increased two and a half times, so that if we weigh eight stone here we should weigh twenty stone there! Imagine playing a game of football under such trying conditions!

However, in one way it is just as well, otherwise everything movable would be blown off the planet when storms occur. From what observers have seen through the telescope, or on photographs taken at short intervals, there must be terrific storms which last for weeks at a time. We can tell this from the rapid changes which take place in the appearance of the clouds encircling the planet. These show that great cyclones are hurling the clouds hither and thither at a terrific rate of speed. When a tornado is raging in America, for instance, people rush out of their houses into underground cyclone cellars and remain there until the storm is over. Then they come out again and look around to see what mischief the storm has worked. Probably they find big trees uprooted, sheds blown down, and their houses standing topsy-turvy in adjoining fields. That is why in places where such storms are common the houses are built of light timber, so that they may easily be put together again.

But what would happen if we lived on a planet like Jupiter, where the storms rage for weeks at a time, and the clouds are driven about so roughly that we calculate the speed of the cyclones as not less than two hundred miles an hour? I expect you are wondering how we know, since no one has ever been to Jupiter. Well, photographs of the planet tell most wonderful stories, and we can imagine the rest.

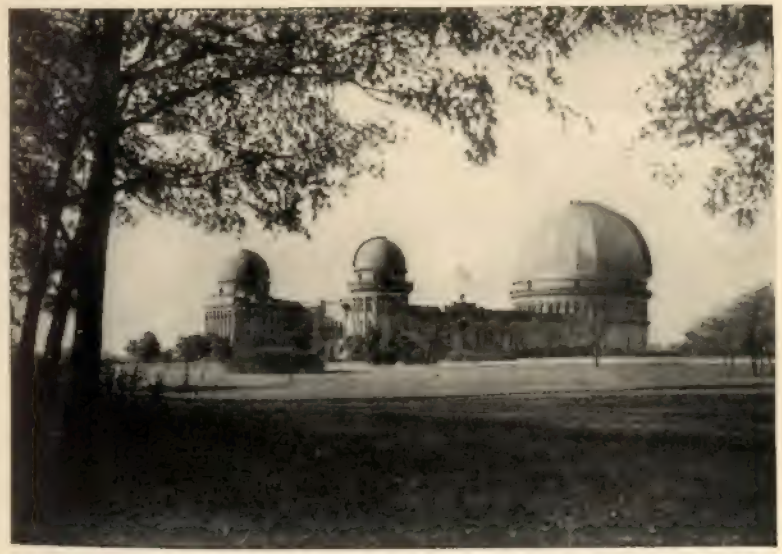
In spite of this turmoil Jupiter appears very bright and wonderful as it glistens in the splendour of reflected sunlight, though "distance lends enchantment to the view." To see the planet at its best ask some one who has a telescope—however small—to let you look at Jupiter. Even with an opera-glass you can see a bright disk and two or three bright points near by. The latter are some of the moons of Jupiter; they were first seen by Galileo through his magic glass a few weeks after the invention of the telescope. The great astronomer was delighted at this view of what looked like a solar system, Jupiter in the centre resembling the Sun, and the little moons encircling planets. He was especially pleased because here was a proof of the theory advanced by Copernicus long before. Some who did not believe in the theory refused to look at the moons through the magic glass. But Galileo did not mind very much; he observed that he hoped they would see them on their way to Heaven.

With a field-glass you may see the four largest moons quite well, and should any of the four be missing you may know that it is either playing hide-and-seek behind the planet, or is buried in the shadow which is cast when Jupiter comes between the Moon and the Sun. The names of the moons are Io, Europa, Ganymede, and Callisto. They are very much larger than the moons of Mars; indeed, they are nearly as large—one is even larger—than our Moon, the largest being 3,600 miles in diameter, or larger than Mercury.

The fifth moon, which has no name, was discovered by an American astronomer, the late Professor E. E. Barnard, in the year 1892, at the Lick Observatory at Mount Hamilton, California. He was probably studying the wonderful markings on the planet's surface when he caught a glimpse of a tiny point of light nestling close by. This happened on a Friday evening, and he could not look again on Saturday, the evening in the week when

LICK OBSERVATORY FROM THE EAST

[See p. 132]



YERKES OBSERVATORY FROM THE NORTH-EAST

[See p. 138]

THE 36-INCH REFRACTOR AT LICK OBSERVATORY 131
With three-prism spectrograph in position

visitors are admitted, until they had left. We can imagine how impatiently he awaited this moment and was free to look again. Then once more, after cutting off the glare of Jupiter, he could see the little moon quite plainly.

Two more moons, known as the sixth and seventh, were discovered also at the Lick Observatory, and they seem to be twins moving in paths that are nearly equal and interlocked. An eighth moon was discovered by Mr Melotte at the Greenwich Observatory while he was examining a photograph of Jupiter with a magnifying glass. At first he thought the speck was a defect on the plate, but when he found it repeated on other plates he knew that he had made a discovery, and he promptly captured the little moon and included it on the list as a member of Jupiter's family. This latest daughter behaves in rather a peculiar way, revolving backward, but this may be because it is farther away from Jupiter than its sisters and asserts thus a desire for independence; but the Sun, which is also pulling on the moon, is to be taken into account. The ninth moon of Jupiter was discovered in 1914 by Professor Nicholson with a telescope known as the Crossley Reflector, a near neighbour of the great Lick Telescope.

Perhaps you may like to hear the story of how the people of California obtained this telescope, as well as something about James Lick, who generously gave it them. He was a millionaire who had worked up from the ranks, for when a lad he was poor, and he had had a hard struggle to earn a living in Pennsylvania. At one time he worked for a miller who had a beautiful daughter. James Lick promptly fell in love with her. In due course he asked the miller's consent to an engagement, but the father objected as the young man was so poor. "But," he said, "when you have a mill as fine as mine, you may come and see me again." Lick took the miller at his word, and went to California, where he did so well that

he was able to buy land. It was the time of the rush to find gold, and when the miners returned from the diggings laden with wealth Lick sold them his land, which he had bought for very little, at an exorbitant price. It was not many years before he had made enough money to build a mill even finer than the one owned by the miller in Pennsylvania, for it was made with the wood of Californian trees.

Then Lick wrote to the miller and reminded him of his promise, but alas! the fickle maiden had married some one else in the meantime. James Lick was disappointed, and this is perhaps why he devoted himself more than ever to making money. There came a time when he thought he would like to spend some of his wealth upon a monument, so that his name might never be forgotten. His first idea was a pyramid, but a friend suggested that this would make an excellent target for enemy artillery should San Francisco ever be bombarded. Some one else suggested that an Observatory built on one of the highest mountain peaks, and containing a giant telescope, would be a wonderful memorial. To this James Lick agreed, and his gift was eventually made with the conditions that he should be buried under the stone pier on which the telescope stands, and that visitors should be allowed into the Observatory on Saturday evenings and permitted to look through the telescope.

The trip up the mountain is well worth while; the trail is twenty-six miles long, winding in and out amid beautiful scenery, and there are three hundred and sixty-five turns, one for every day in the year. The first time I took the trip I was alternately admiring the scenery and wondering whether the next jolt would land us in the valley below. At last we came to the "Oh, my!" turn, so called because this exclamation is usual on rounding an extremely sharp bend which suddenly brings the Observatory into view.

There it was, standing clear-cut against the blue sky,

which was just beginning to turn grey with the approach of twilight. Members of the staff were awaiting the arrival of my party, and one by one we were given a peep at Jupiter through this magic glass with a lens thirty-six inches in diameter. We were shown the great red spot on the planet first discovered by the astronomer Hooke in 1664. It seems to have outlived the changes of time and the great storms on Jupiter, although we were told that it is a mere ghost of its former self. It has a way of appearing and disappearing at intervals, and the suggestion has been made that it is caused by a vortex like a cyclone on the Earth, deep below the planet's visible surface.

A lady of the party desired to see the Moon and was very annoyed when told that it was New Moon just then, and therefore not visible. She complained that she had spent five dollars on the trip for the one purpose of seeing the Moon, and some one suggested that the money ought to be refunded as she had been led to spend it on false pretences. To mollify her she was shown three of the moons of Jupiter, and when told that one was larger than our Moon she went away satisfied.

In *Starland* Sir Robert Ball tells the story of a visitor to the Observatory who sent in his name with an introduction to the astronomer and a request that he might enter the temple of mystery. The astronomer made him welcome and asked what he desired to see.

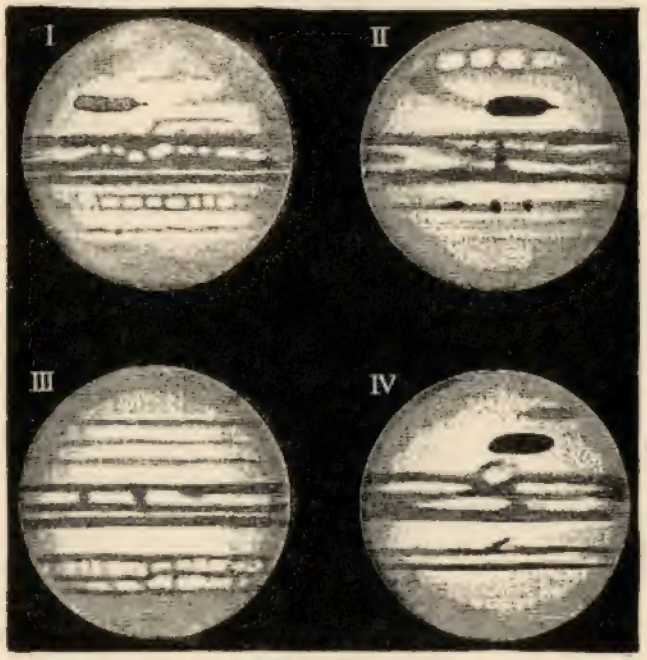
"Oh!" said the visitor, "I have come to see the Moon—that is the object in which I am specially interested."

"My dear sir," said the astronomer, "I would show you the Moon with pleasure if you were here at the proper time. It will not rise until about half-past two to-morrow morning, and it is only nine o'clock now. Come back in five or six hours, and you shall observe the Moon through the great telescope."

The visitor evidently thought that the astronomer

was trying to put him off, and he was equal to the occasion.

"Of course the Moon is not up," he replied; "anyone can see that, and that is why I have come, for *if the Moon had been up I could have seen it without your telescope!*"



VIEWS OF JUPITER
From "In Starry Realms," by Sir Robert Ball

Before we leave the Prince of planets you may like to hear a little more about the four moons of Jupiter which were discovered by Galileo. With a strong opera-glass one or two of these may be seen, but keep on watching them evening after evening and note what happens.

When Galileo first turned his telescope on Jupiter he saw only the planet—round like the Sun or Moon. He looked at it again on January 7th, 1610, through a more

powerful telescope and was surprised to see three small but very bright stars quite close to the great orb, two on the east side and one on the west. Next evening he saw that the three stars were now on the west and nearer to

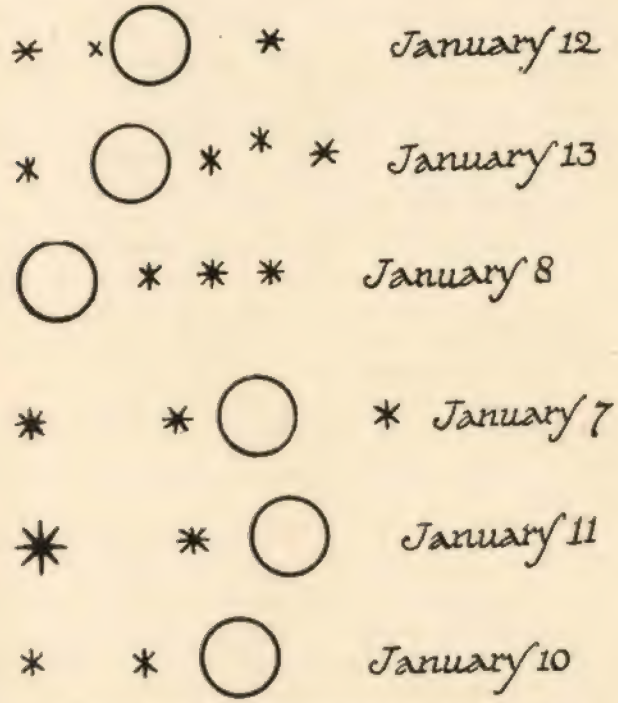


DIAGRAM TO ILLUSTRATE GALILEO'S OBSERVATIONS

each other than on the previous evening. Galileo was puzzled, and thought that perhaps the planet had got in advance of the stars in some way.

He therefore waited for the following night with great anxiety, but his hopes were disappointed, for clouds covered the sky. On January 10th he saw only two stars; they were almost equal in size and were both on the same side of Jupiter. Perhaps, he thought, the third might

be hidden behind the planet. We can imagine that the astronomer was very excited when he got out his telescope on the 11th; but again he saw only two stars. They were still on the east side of Jupiter, but one appeared nearly twice the size of the other.

At last his suspicions were aroused. On the 12th he saw again three stars, two on the east side of Jupiter, and one on the west side. The third began to appear about three o'clock in the morning, coming out to the east of the planet, and it was exceedingly small and difficult to see. But on the 13th Galileo saw four stars, three of them on the west side of the planet, and the remaining one on the east side. They were all arranged in a line with the centre of the planet, they appeared of the same brightness, and though small were very brilliant, shining with a much greater lustre than fixed stars of the same magnitude or brightness.

Galileo was rewarded for his patient watches each night by learning that the 'stars' were not stars, but moons or satellites which kept Jupiter company during his yearly journey round the Sun.

Soon after this discovery tables were made showing when and on which side of the planet the moons could be seen, as well as when they would be eclipsed, or hidden by going behind the planet. But evidently there was a mistake in the calculations, for at times the eclipses would take place fifteen minutes too soon or fifteen minutes late. A Danish astronomer, Olans Roemer, in 1675 found out the reason—that it is because the light 'message' from the moons arrives later when Jupiter is at its greatest distance from us. Then light takes time to travel, he concluded wisely, and when he had worked out the problem, the distance of Jupiter when at its nearest and greatest being known, he found that light travels at the rate of 186,330 miles, or nearly two hundred thousand miles a second. It goes so quickly that it would rush more than seven times round the Earth in a

single second. When Jupiter is nearest to us we receive the light in 34 minutes; when it is farthest, in 51 minutes. This was an extremely important discovery, but it was fifty years before it was generally accepted by astronomers.

The time of the appearance and disappearance, or eclipse, of the moons of Jupiter, and their position with regard to the planet, can be found in the *Nautical Almanac*, and provided with an opera-glass or field-glass a boy or girl can observe the planet and its satellites without difficulty on a clear night. If the young observer will make a drawing of the position of the moons and compare this with the *Almanac*, it will be seen how accurate are the calculations.

CHAPTER X

SATURN, THE RINGED PLANET

A marvel of design—a mystery
Of beauty, poised within those silent depths!
ARTHUR MEE

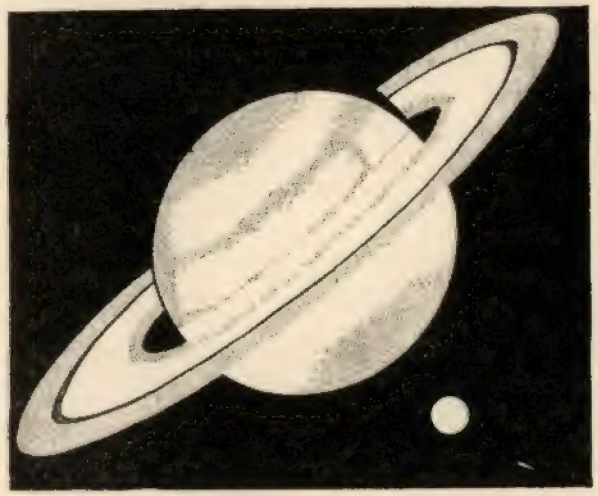
SATURN, for all its magnificent series of rings and stately train of nine satellites, had an evil reputation in olden days. It was named after the god Saturn, the father of Jupiter and a descendant of the race of Titans, children of Earth and Heaven, which sprang from Chaos.[1] Saturn is sometimes confused with the Greek god Kronos, the god of Time, who was said to bring all things to an end. Hence his symbol is an ancient scythe, by which the planet is indicated in almanacs.

Saturn was described as "slow moving, leaden and sullen," but its dull yellow colour is due to the fact that it is nine and a half times as far from the Sun as we are, and receives but one-hundredth the amount of light and heat which is bestowed upon our Earth. It only seems to be 'slow-moving' since it is speeding along at the rate of six miles a second. Its annual journey round the Sun occupies nearly thirty years, so vast is its orbit.

The planet is a very wonderful object when seen in a giant telescope, as I was able to appreciate when I observed it through the forty-inch lens of the telescope at the Yerkes Observatory, at Williams Bay, Wisconsin. It was an experience never to be forgotten. Outlined against the dark blue background of the sky was the golden-brown disk of the planet with its rainbow-tinted hues,

[1] See *The Myths of Greece and Rome*, by H. A. Guerber.

seemingly suspended in some mysterious way within the curving outline of the encircling rings of shimmering gold. Through the faintly transparent crape ring the outline of the planet could be seen, and on each side of it a dark gap of nearly ten thousand miles in width. Within this space there would be ample room for the Earth to



SATURN COMPARED WITH THE EARTH

circulate without touching either Saturn or the rim of the innermost ring.[1] The width of the ring is thirty-eight thousand miles, and the span of the ring-system from side to side is a hundred and sixty-eight thousand.

The diameter of Saturn is seventy-three thousand miles, or a little more than nine and a half times that of the Earth, but apparently it is composed of such light material that its mass is only ninety-five times that of our planet. According to Sir Robert Ball, "If we could conceive a vast ocean into which a globe equal to Saturn in size and weight were cast, the great globe would not sink like the Earth, but would float buoyantly at

[1] The Earth is 7,920 miles in diameter.

the surface with one fourth of its bulk out of the water."

Saturn is enwrapped in an envelope of clouds, but whether they surround an intensely heated gaseous interior with nothing solid within, or whether the interior is cold, like a compact snowball covered with a mantle of snowflakes so feathery in texture as to resemble clouds, is a problem as yet unsolved. One thing, however, appears to be certain, that is, the planet cannot be an inhabited world like ours.

Some one once made the fanciful suggestion that the rings of Saturn are peopled with inhabitants. At that date the rings were thought to be solid. Now we know that even if they were composed of the toughest steel the attraction of Saturn would pull them to its surface. So great would be the pressure that the rings if solid would bend like putty.

This recalls the fable of the oak-tree and the pliant reed. A storm arose, and a mighty wind lashed the oak-tree and the reed with fury. The sturdy oak laughed at the reed, saying it would never be able to withstand the blast ; but as it turned out the oak was blown down, and the reed, bending this way and that as the wind tossed it about, was as sprightly as ever when the storm had ceased.

We get from this story a hint as to the nature of the rings, which we know are composed of myriads of moonlets, particles not more than a few yards across. They have even been termed ' brickbats.' Each pursues its independent path in the ring-system, though some jostle each other, like a crowd of boys and girls hurrying out of school to the playground in the afternoon. The illustration may be carried a step farther. Boys and girls coming from school at playtime rush with all speed to the playground lest a teacher should suddenly recall them. Those in sight of the playground and at the greatest distance from the teacher slacken speed as they

feel safe from such a misfortune. Thus, the particles composing the innermost of Saturn's rings race at full speed to avoid being drawn on the surface of the planet, while those on the outermost ring travel in a more leisurely fashion, being farther removed from the danger zone.

Professor G. H. Darwin had many interesting things to tell us about our Moon ; he also made a special study of the particles which compose Saturn's rings. He compares the moonlets to meteors dashing through space at the rate of twenty-five miles a second. Should these come too near our planet and plunge into its atmosphere they rub against every particle they meet. This friction causes them to blaze out, and they vanish in a flash of intense light. If any particles are left they sink upon the surface of our planet as grains of dust. Millions of meteorites are thus consumed during the course of a year. Now, says Professor Darwin, the same fate overtakes moonlets which daringly venture into the No-man's-land separating the edge of the ring from Saturn ; they are drawn into the planet's atmosphere and vanish.

As for the particles on the outer edge of the ring, if they persist in banging into each other without looking where they are going, they are bound in the course of time to get mixed up together as in a Rugby scrum. The group may end in a whirl like a gigantic football, and perhaps turn into a little moon. Who knows ? Or other particles of a gentler disposition may form a mutual admiration society circling round a particularly attractive 'brickbat,' uniting and thus adding another moon to the satellite system of Saturn, about which we shall read later.

Were it possible to build a Time Machine, such as Mr Wells describes in his well-known book, we might mount it one fine night and, by pulling the lever pointing to the *Future*, advance some million, million years into the future, to witness some such scene as this.

In a region of the sky blacker than any night we have ever known, and cold enough to freeze us into solid blocks of ice, we should view Saturn enwrapped in folds of delicately tinted clouds, and rotating on its axis at the rate of ten hours and fourteen minutes a day. Surrounding the planet, though at a distance of ten thousand miles, we should see the rings—a study in perpetual motion, some of the particles vanishing before our eyes, others in process of grouping into infant moons. There is no knowing how many more satellites will thus have been formed when this remote distance of time shall have been spanned.

By reversing the lever of our machine we return through space beyond our starting-point until we reach the seventeenth century, in which Galileo lived. We see the old astronomer with his telescope gazing earnestly at the heavens. You may remember how the wise men of his day refused to believe him when he said that Jupiter was the centre of a solar system. He had watched the four attendant moons through his magic glass and was convinced that these circled round the planet, just as Mercury, Venus, and Mars circle round the Sun, but they laughed him to scorn.

In imagination we see him turn his telescope in the direction of Saturn and witness his surprise at finding two bright starlike objects which seem to support the planet on either side.

But let us come back to Earth and look up the records of that discovery. Galileo confided it to his friend Kepler in November 1610, telling him that, "Saturn consists of three stars in contact with one another." He announced his theory to the world of science by transposing the letters of a Latin sentence. When translated the message reads, "I have observed that the most distant planet is triform." He did this in order that other astronomers should not be able to claim the credit of the discovery.

DRAWINGS OF SATURN AND HIS RINGS 142

By the late Richard A. Proctor

(1) February 2nd, 1862. (2) November 3rd, 1858. (3) March 23rd, 1856

From *Saturn and its System*

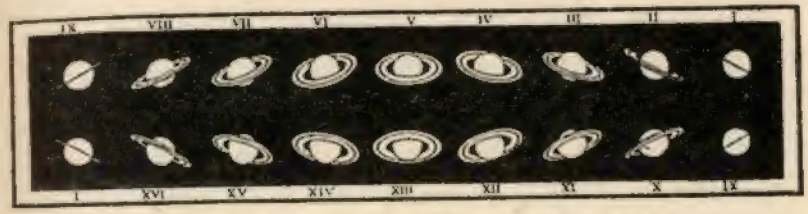
By permission of Messrs Chatto and Windus

SIR WILLIAM HERSCHEL AND HIS SISTER AT THE TELESCOPE

[*See p. 146*]

Saturn, the Ringed Planet

When he examined the planet again in 1612, after an interval of a year and a half, Saturn was as smoothly rounded as the disks of Jupiter or Mars, and the two bright companions had vanished. Galileo rubbed his eyes and looked again through his magic glass until he realized that nothing was visible except the planet. "Is it possible," he exclaimed, "that some mocking demon has deluded me?" Then other changes took place during the next few years in the appearance of the



CHANGES IN THE APPEARANCE OF SATURN'S RINGS

planet which were still more puzzling. The bright objects reappeared and grew larger and larger, varying strangely in form; finally they lost their globular appearance and seemed like two mighty arms stretched toward and held around the planet. The ring disappeared again in the year 1626, and Galileo was never able to explain what he had seen, for his sight gradually failed him and in 1637 he became blind. The changes he had been watching were due to the fact that as Saturn circles round the Sun the rings do not always present the same appearance. Every fifteen years we see the rings 'edge on,' when for a time they disappear altogether or are only visible in large telescopes. Here they appear as a fine line of light across the surface of the planet. They gradually reappear and open out until they are again at their widest. This condition will occur in 1928, and if an opportunity is afforded for looking at Saturn through a telescope, or even a powerful field-glass, take advantage of it, for it will be well worth while. Seeing is believing,

and personal observation is more valuable than book knowledge.

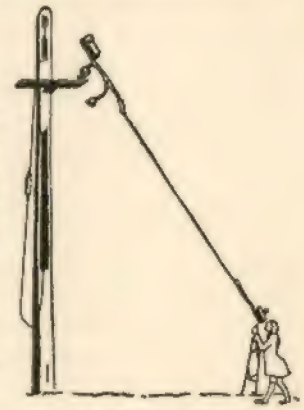
Until Herschel's time, the satellites were called 'First,' 'Second,' etc., according to their distance from the planet, but as Sir William Herschel discovered two new satellites which were within the orbits of those which were known before, their discovery confused matters, especially when an eighth moon named Hyperion was discovered by W. C. Bond, of Cambridge, in September 1848, and independently by William Lassell at Liverpool two days later. So names were assigned to them by Sir John Herschel as follows, beginning with the most remote: Iapĕtus (Hyperion), Titan, Rhea, Dione, Tethys, Encelădus, Mimas. (The name Hyperion was not given by Sir John Herschel, but put in after its discovery by Professor Bond.)

Titan, the very suitable name for the largest moon, was discovered by an astronomer C. Huyghens, of Holland, in 1655. It can be easily seen with a three-inch telescope, and is about as large as Mercury, having a diameter of about three thousand miles. It goes round Saturn in a little less than sixteen days.

Four of the moons, namely, Tethys, Dione, Rhea, and the more distant Iapetus, are fainter and need a more powerful telescope to bring them into view. They were discovered by Cassini, a celebrated Italian astronomer, in 1675, with the queerest-looking telescope imaginable. The length of the instrument, or rather the distance at which the object glass was placed, was one hundred feet or more from the eye of the observer. A tube was dispensed with, and a long wire of proper length connected the eyepiece of the telescope with the object glass. Observation with such a telescope must have been wearisome, but it was with such seemingly clumsy tools that the old astronomers made their wonderful discoveries.

Two more of the moon family, Mimas and Encelădus,

were discovered by Sir William Herschel. A ninth, Phoebe, was detected by Professor W. H. Pickering while examining a photograph taken at the Arequipa Observatory in 1898, and a possible tenth, which, however, is not entirely beyond suspicion, was discovered by him in the same way, and is named for the time being Themis.



CASSINI'S TELESCOPE

Mimas, the nearest and smallest of the moons, coasts round the far edge of the outer ring, at a distance from it of only thirty-four thousand miles, during a period of 22½ hours. This moon is so very near the ring-system that it causes disturbances amid the 'brickbats,' some of which are drawn inward by the powerful attraction of Saturn and away from Mimas, while others are pulled outward toward the moon. This it is which explains a great gap two thousand miles wide and as clear of 'brickbats' as though a path had been swept with a celestial broom. The division in the rings was first observed by Cassini with his strange telescope, and is known as Cassini's Division. With a small telescope it can be seen as clearly as if drawn in black ink with a finely pointed pen.

The discovery of Mimas by Sir William Herschel, the "vigilant watcher of the skies," was due to the peculiar way in which this bright object seemed to swing on the edge of the ring for at least twenty minutes before finally taking what seemed to be a plunge into oblivion. This curious conduct interested Herschel to such a degree that he hurried the completion of a large telescope which was being made and, indeed, did not wait until it was finished before turning its forty-inch eye upon the stranger.

This was on August 28th, 1789, and on September 17th

a companion, Enceladus, stood revealed to view! The two seemed to be playing a game of some kind, and when they could be seen under favourable conditions Herschel watched them threading their way like beads of light along the now almost vanishing ring.

The smaller and fainter moon, Mimas, was first seen by Herschel with the great mirror which measured nearly fifty inches across, and weighed 2,118 pounds. It was slung in a ring, and the sheet-iron tube in which it rested was thirty-nine and a half feet long, and four feet ten inches wide. Ladders fifty feet in length had to be climbed to get to a movable stage on which Herschel used to stand while making his observations. When he wanted to speak to his assistants, he called to them through a speaking-tube. The whole erection stood on a revolving platform, and two workmen were engaged to move it by hand, according to the directions given by Herschel.

We realize his patience and energy when we read that each night the telescope was directed three times at each part of the field of view, so that every object was thrice examined, and nothing could escape his notice. Nor was he affected by the weather, if we may judge from the account given by a visitor who once shared his nightly vigil. "The thermometer in the garden stood that night, January 6th, 1785, at 13 degrees Fahrenheit, but the royal astronomer has an excellent constitution, and thinks about nothing else in the world but celestial bodies."

Herschel had great hopes of his giant reflector, but the climate affected it seriously. It had a way of becoming dewed in moist weather, or frozen up in cold, and despite all the care he lavished upon it the delicacy of polish upon its surface could not be preserved more than two years. Gradually its "broad, bright eye" grew dim, and it was used for the last time on January 19th, 1811. It was left standing, framework and all, until

New Year's Eve, 1839, when it was dismantled with due ceremony. A 'Requiem' composed by Sir John Herschel, the astronomer's son, was sung by his family, fourteen in number, assembled within the tube, which was then riveted up and laid horizontally on three stone piers in the garden at Observatory House at Slough.

I saw the memorial for the first time on a May morning. A downpour of rain had just ceased, and the sunlight shining on the raindrops bedewing the tube, painted a deep olive-green, gave it the effect of burnished copper. Trees wave their branches over it, and bushes form a background to this fitting memorial to the memory of one of the greatest astronomers the world has ever known. He has been termed "the explorer of the heavens," and he strove to break the barriers which hid its wonders from view. The speculum, or mirror, adorns the hall of Observatory House, and, gazing upon that surface now dimmed by time, one recalls how Herschel described Sirius appearing therein "with all the splendour of the rising sun, and forced me to take my eye from that beautiful sight."

CHAPTER XI

THE STORY OF HERSCHEL'S PLANET

WHEN Herschel discovered Saturn's two moons, Mimas and Enceladus, he had already made a great name by the discovery of Uranus on March 13th, 1781. This was known at first as Herschel's planet, and its symbol is the initial letter of 'Herschel,' with a disk suspended from the crossbar to represent the planet.

In those days Herschel was a noted musician, teaching music at Bath, composing chorales and anthems, and occupying the position of organist at the Octagon Chapel. However, his main interest lay in science and mathematics; every spare moment of the day and many hours stolen from the night had been devoted to this study, and after reading of the wonders of the heavens Herschel borrowed a small telescope so that he might see more of them for himself.

The result was so enthralling that he made up his mind to get a telescope of his own. But when he inquired the prices and found that they were beyond his slender means, he decided to make one for himself. He happened to know of a Quaker neighbour who had made attempts at polishing mirrors, but without success, so he went to see the man and was able to buy his tools, polishers, and unfinished mirrors. The latter were small, not more than three inches in diameter.

Nothing could be done until the music lessons came to an end at the beginning of June 1773. Then work began in earnest. The house was turned topsy-turvy, a cabinet-maker was installed in the drawing-room, and a

huge lathe was set up in one of the bedrooms. His sister, in spite of secret dismay at such unruly proceedings, lent a hand, and kept meals going. William directed, inspired, toiled, with the ardour of a man who had staked his life on the issue.

Herschel scarcely allowed himself time for his meals, and on one occasion when he found it necessary to remain with his hand on the mirror for many hours his sister fed him with a spoon. While he was turning lathes and polishing mirrors she read to him, and among the books selected were *The Arabian Nights* and *Don Quixote*. At last, after *two hundred* failures a fairly good reflector was made. By this time Herschel was becoming an expert in the art of making mirrors.

His great ambition was to bring reflectors to such perfection that he might be able to scan the farthest corner of the heavens. He felt amply rewarded when during a survey his keen eyes detected the presence of an unknown object in the group of stars known as Gemini, the Twins. He knew at once that it could not be a star, because a star, however bright, never appears except as a point of light, owing to its enormous distance from the Earth. The object was larger and brighter than a star, and moreover it was a neat round disk. If it was not a star then it must be a comet, argued Herschel; for it never occurred to him that it might be another planet belonging to the family of the Sun.

Then he tried to calculate the orbit of the comet, but without success, and after much thought he began to suspect the truth. Finally, in 1783, he wrote a letter to the President of the Royal Society in which he made the following statement: "By the observations of the most eminent astronomers in Europe, it appears that the new star, which I had the honour of pointing out to them in March 1781, is a primary planet of our Solar System." He then suggested that it should be called Georgium Sidus in honour of his patron King George III, but his wish

was not generally honoured on the Continent. It is true the planet was referred to in the *English Nautical Almanac* until the 1847 issue as 'the Georgian,' but the name Herschel, proposed by Lalande in honour of its discoverer, was in general use for many years. In Burritt's *Geography of the Heavens*, published in 1846, the planet is called Herschel, and in *Astronomical Discovery* the author, Professor H. H. Turner, writes as follows :

> Only the other day I was interested to see an old pack of cards used for playing a parlour game of Astronomy, in which the name Herschel is used. The owner told me that they had belonged to his grandfather, and that the date of publication was in 1829, and the place London, so that this name was in common use in England nearly half a century after the actual discovery.

Bode, a German astronomer, was in favour of continuing the naming of the planets after ancient divinities, and his view prevailed, with the result that the planet is now generally referred to as Uranus, after the name of the most ancient of the gods. When its discovery became generally known, every one asked, " Who is this organist at Bath ? "

Even King George III was interested, and he directed that the astronomer be summoned to Buckingham Palace to give an account of his wonderful discovery. Herschel went without delay, taking his seven-foot telescope with him ; he also provided himself with a map of the Solar System, so as to give the King an exact idea as to where the newly discovered wanderer was to be found. Herschel presented this drawing to the King, and on July 2nd, 1782, he made his first appearance as showman of the heavens at Buckingham House, near Buckingham Palace. Fortunately the skies were clear, and the King and Queen were able to see not only the new planet, but Saturn as well.

When the Princesses heard about the wonderful sights their parents had seen, they asked that these might be

shown to them next day, but as they objected to standing about on the damp grass (not being as sturdy as Caroline) Herschel moved the telescope into the Queen's apartments. The sky was overcast, and while Herschel was waiting for the clouds to roll away he entertained the Princesses and their ladies with an account of his various instruments.

We can imagine the youngest of the Princesses becoming weary of these details, which were a little beyond her, and asking with a sigh when they were to see the wonderful things in the sky. Herschel had very wisely anticipated this request, as will be seen from the following letter written to his sister Caroline :

> When the evening appeared to be totally unpromising, I proposed an artificial Saturn as an object, since we could not have the real one. I had beforehand prepared this little piece, as I guessed by the appearance of the weather in the afternoon we should have no stars to look at. This being accepted with great pleasure, I had the lamps lighted up which illuminated the picture of a Saturn (cut out in paste-board) at the bottom of the garden wall. The effect was fine, and so natural that the best astronomer might have been deceived. Their royal highnesses and other ladies seemed to be much pleased with the artifice.

The interest taken in Herschel's work by the King resulted in the " observer of the skies " receiving the appointment of Royal Astronomer, with the modest salary of £200 a year. " Never," exclaimed Sir William Watson on hearing the news of the amount, " bought monarch honour so cheap ! "

However, the sum was a welcome addition to Herschel's income. It released him from financial worry and the need for teaching and giving concerts. Ulysses starting from Ithaca to " sail beyond the sunset " was not more eager than was Herschel to give all his time and energy to exploring the great Unknown.

But his position as Royal Astronomer brought with it certain trials, for according to his sister's diary great folk were constantly calling and asking to be allowed to

look at this or that celestial object through the telescope, which had become "all the rage." As a specimen of some of the quaint questions asked at that time, the following note left by an exalted visitor who "stept in" and was not so fortunate as to find anyone at home is interesting:

> The Prince of Orange has been at Slough to call at Mr Herschel's and to ask him, or if he was not at home to ask Miss Herschel, if it is true that Mr Herschel has discovered a new star, whose light was not as that of the common stars, but with swallow tails, as stars in embroidery. He has seen this reported in the newspapers, and wishes to know if there is any foundation to that report.—Slough, the 8th of August, 1798.
>
> W. PRINCE OF ORANGE

We shall hear more about Herschel's work later, and how he "strove to break the barriers of the heavens." At the moment we will turn again to the planet with which his name was particularly connected.

COMPARATIVE SIZE OF URANUS AND THE EARTH

In the telescope Uranus shows a greenish disk, and there are faint traces of belts resembling those of Jupiter. It appears as a star which though faint can be seen without a telescope by those who have good eyesight. Its diameter is nearly 31,000 miles, its day, or the time that it rotates on its axis, is ten hours fifty minutes, and it takes eighty-four years to go once round the Sun. Consequently, while our planet has been revolving round the Sun eighty-four times, Uranus has done so only once. The planet is about 1,800,000,000 miles from the Sun, a distance about nineteen times as great as that of our planet. Were the Earth removed to that distance it would receive

but one-three-hundredth part of the light and heat to which we are accustomed.

Uranus has four moons, Ariel, Umbriel, Titania, and Oberon. The two brightest, Oberon and Titania, were detected by Sir William Herschel a few years after he had discovered the planet round which they circle. Ariel and Umbriel were discovered by Lassell in 1851. They are among the smallest bodies in the Solar System, and the most difficult to see. Like the sixth, eighth, and ninth moons of Jupiter, and Phoebe, the ninth moon of Saturn, the four Uranian moons revolve backward. The paths of the moons are almost perfect circles, as if drawn by a celestial compass. They are also closely packed, as if the moons wished to keep in touch with each other, the distance of Titania, the outermost, being 280,000 miles, somewhat greater than that of the Moon from the Earth.

CHAPTER XII

NEPTUNE, SENTINEL OF THE SOLAR SYSTEM

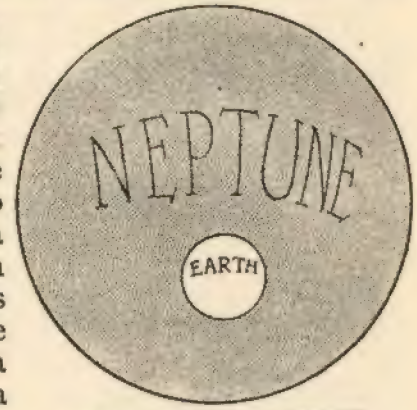
WE must travel millions of miles in space if we wish to arrive at the shores of the outermost planet, Neptune, sentinel of the Solar System. Although it had been mistaken for a star no less than nineteen times, its claim to membership in the Sun's family was not established until the twentieth glimpse, which took place in the year 1846. Even then the astronomers were told where to look for it by two rival mathematicians who did the hard work of tracing its position in the sky, so that the astronomer had only to point his telescope in the direction indicated. Though he saw the planet first, he was not its discoverer.

Before I tell the story of the discovery, one of the romances of astronomy, you may like to know a few facts about the planet. It was, of course, named after the god of the sea, and if you will turn to p. 29 you will see that its symbol is a trident. It is not surprising that the nature of Neptune was not detected easily, because it shines very faintly and can only be seen with the aid of a telescope or a good field-glass, and then providing that you know where it is to be found in the sky.

There are two reasons why Neptune is so faint ; first, its enormous distance from the Sun, thirty times as great as that of our planet ; second, the small amount of light it receives in consequence—only one-nine-hundredth part of the Earth's allowance. Planets, of course, shine only with reflected light from the Sun.

Seen from Neptune the Sun must present the appearance

of a large electric arc lamp at a distance of a few feet, the light being equal to that of nearly seven hundred full Moons. This would be quite enough to enable a visitor to find his way about. However, as the planet is enwrapped in a blanket of dense clouds we have no idea of what its surface is like. Nor are there any prominent marks or spots which would help us to calculate the speed with which the planet twirls around, as in the case of Mars. Therefore we do not know the length of a day on Neptune although we know the length of its year. Ambling along at the 'slow' rate of 3⅓ miles a second, Neptune takes a period equal to 165 years on Earth to complete one journey round the Sun. Therefore a boy would not reach the age of ten years on Neptune until 1,650 years had passed on Earth! Neptune is about 33,000 miles in diameter, or four and a fifth times the diameter of the Earth.



COMPARATIVE SIZE OF NEPTUNE AND THE EARTH

With this preface I will now tell you the story of the two mathematicians who helped the astronomers to find Neptune. The problem they had to solve was one to tax the keenest brains on Earth, and it required two years of intense study to solve it. Supposing one fine morning when you arrived at school you found this question staring you in the face, on the blackboard : " If Uranus is a second or so late in arriving at the point on its path where it should be, according to Herschel, what is the size, mass, and distance of the object which is causing the delay ? "

Should your teacher insist that those who failed to

solve the problem should remain in school until they did so, I fear you would all be very late home to dinner! Your teacher, who does not like to go back upon his word, would have at last to do so, for, as we have just seen, even one of the greatest mathematicians the world has ever known could not find the answer in less than two years. However, he had the satisfaction of knowing that his answer was right, though he nearly lost the credit of being first in the field. There was a close second whose position enabled him to test his theory without delay and to command the ear of the scientific world. Consequently his discovery was widely known when only two or three people knew about his rival's superior claim.

The two rivals were John Couch Adams, an Englishman, and Urban Leverrier, a Frenchman. Quite unknown to each other both were trying by means of mathematics to find an answer to the query: "Is there a planet beyond Uranus, and, if so, where is it to be found?"

Adams was born at Lidcot in Cornwall on June 5th, 1819, and his father was a farmer. The farmhouse where Adams spent his childhood is still standing, and marks made by the lad on the window-ledge showing the position of the shadows at noon are still to be seen. At an early age Adams loved to spend his time in the library which his mother had inherited from her uncle, and it seems that he was very fond of books on astronomy. Although these were too difficult for the boy to understand, we can imagine him enjoying pictures of the Sun, Moon, and stars, and we are told that on fine nights he would try to trace the outlines of the star groups, or constellations, for himself. He made drawings of the star-positions in the constellation Orion, for instance, comparing them with the chart in a book.

At the age of ten he was sent to the village school, where he learned all that his master could teach him. When he was twelve years old he continued his studies

with an uncle who lived at Devonport. By this time his father had long given up the idea of making the boy a farmer—he was far more interested in stars than in sheep. So arrangements were made to give him a university education, and in 1839 he was sent to St John's College, Cambridge. He was then nearly twenty years of age.

Adams spent most of his leisure hours in the College library, where he read an account of a meeting of the British Association in 1831–32, and became deeply interested in a discussion concerning the strange movements of Uranus, which was not keeping exactly to the orbit worked out carefully for it by Sir William Herschel.

This great astronomer had continued to observe the planet until his work on Earth came to an end, when others took up the task. In 1821 an astronomer named Bouvard, on turning his telescope to where the planet should have been, found it was not there. It appeared a second or so later, and you would hardly believe that so much fuss could have been made of what seems to us such a trifle.

Astronomers called the difference an 'intolerable quantity,' and on thinking of what resulted from its detection we can understand that even seeming trifles may mean much in an exact science like astronomy.

At the meeting of the British Association some had said that the delay was due to another planet beyond Uranus. Sir George Airy, the Astronomer Royal, doubted whether such a planet existed, and predicted that even if it did exist it would never be found.

Young Adams made up his mind that as soon as he had taken his degree he would make a search for the missing planet. So in 1843, when he graduated as Senior Wrangler, he sat down to his self-appointed task.

Through the kindness of Professor Challis, at that time Director of the Observatory at Cambridge, he was able to obtain Bouvard's observations and other papers from

Greenwich Observatory, and at the end of two years he went to Professor Challis and told him that he had solved the problem. Adams was not yet twenty-six, but by the intensest study and application of mathematics he had succeeded in tracking the planet to its lair. Step by step he had traced it, through study of its disturbing effect on Uranus, until at last he could point to a spot on the star-chart and say with perfect confidence, "That is where you will find the planet."

We can imagine the surprise of Professor Challis, for here was a young man who had taken his degree only two years before actually prepared to show where a new planet was to be found, thus proving the Astronomer Royal to be wrong when he predicted that it never would be found. However, Challis suggested to Adams that he should go to the Astronomer Royal with his papers, and tell him of his discovery.

Here the tragedy begins, for when Adams, filled with enthusiasm, called at Greenwich Observatory with a letter of introduction from Professor Challis he was told that Sir George Airy was not at home. The young man called again a month later, and again the Astronomer Royal was out, so Adams left a note for him and said that he would call back later. The message read:

> According to my calculations the observed irregularities in the movements of the planet Uranus may be accounted for by supposing the existence of an exterior body, the orbit of which is as follows, etc.

This note has been preserved, and bears the date, "October 1845," in the handwriting of the Astronomer Royal, for Adams himself put no date to this most important document.

When Adams called an hour later he was told by the butler that his master was at dinner and could not be disturbed. "Was there any reply to my message?" asked Adams, but there was none, and he went away feeling hurt and discouraged.

However, the Astronomer Royal did reply later; he asked a question which seemed so trivial that Adams, feeling that Airy was doubtful of the accuracy of his calculations, did not reply to it.

Professor Challis did not inquire as to the outcome of his young friend's interview with the Astronomer Royal, and as he did not show any further interest in the matter Adams was too hurt to let him know what had happened. Professor Challis must bear some of the blame for the misfortunes which prevented Adams from publishing his claim until after the planet had been actually found through the directions of Leverrier.

Leverrier, a brilliant mathematician, was born in Normandy in 1811 and was therefore eight years older than Adams. At the time he comes into our story he was the Professor of Astronomy at the Ecole Polytechnique, founded by Napoleon, so that he was already a famous mathematician. He published his first paper on Uranus in November 1845 (a month after Adams had completed his calculations); in June 1846 he announced to the world where the suspected planet could be found.

Airy received a copy of the last paper before the end of the month, and we are told that later on comparing Leverrier's calculations with those made by Adams he found that the position assigned by Leverrier for the planet was within one degree of that indicated by Adams eight months earlier. He thereupon wrote to Challis directing him to make use of the Northumberland telescope at the Cambridge Observatory, for that purpose.

Challis commenced a series of observations around the section of the heavens where the planet was to be looked for, and made a record of all the stars he saw. He actually included the object sought after on three occasions, but failed to recognize that it was a planet and not a star. If only he had had the keen eyes of a Herschel, or if there had been a chart of that particular part of the heavens

at Cambridge Observatory, he would, on comparing his observations with the positions of stars marked on the chart, have at once detected the wanderer.

Meanwhile Leverrier, having finished his calculations, was able to indicate the spot on the ecliptic (the roadway in the heavens along which the planets travel) where the planet was to be found. But its existence must be proved, so not having the necessary instruments, charts, or the skill of a practical astronomer he wrote to Dr Galle, Director of the Observatory at Berlin, knowing that he possessed all three. "Point your telescope," said he, "to the neighbourhood of the constellation of Aquarius, and you will find within a degree of that place a new planet, looking like a star of about the ninth magnitude, and having a perceptible disk."

On the night of September 23rd, 1846, Dr Galle followed his friend's directions, and in the place indicated, within half an hour of the time he began looking for it, he found the planet almost exactly at the precise point where Leverrier said it would be. He was fortunate in having in his possession a chart of that particular region of the heavens which although engraved and printed had not yet been sent out to others. This was of immense assistance and, of course, it gave him a great advantage over the English astronomers. The news of the discovery flashed over Europe at the best speed at which news could travel in those days, and by October 1st Airy, Challis, and Adams learned that England had been forestalled in the interesting discovery.

Writing to Airy on October 12th Challis lamented that after four days of observation he would have found the planet if only he had not delayed comparing his successive observations with each other. Had he done so, he must have at once detected that a supposed star had changed its position from night to night, showing that it was not a star, but a planet. Challis actually recorded the planet as a star early in August, but he did

not find this out until after the announcement of the discovery of the planet had been made by Leverrier.

It was unfortunate that Adams did not answer Airy's 'test question,' for had he done so Sir George's interest might have been secured. When the Astronomer Royal sent the same query to Leverrier the latter answered it within three or four days. In the acknowledgment which Airy wrote to Leverrier he did not mention the splendid work of Adams.

Naturally the French were very annoyed when they learned of the claim to a share in the great discovery set up later on behalf of an unknown Cambridge graduate.

You may imagine the feelings of Englishmen when it became known that, but for the unfortunate circumstances I have described, the discovery might have been made months earlier. Sir George Airy in giving his account of the transaction made the following candid statement, which completes the story:

"I consider it quite within probability, that a publication of the elements [of the planet's orbit] obtained in October 1845 [from Mr Adams] might have led to the [telescopic] discovery of the planet in 1845, seven months before Leverrier disclosed his calculations."

During the course of a Christmas lecture given to children at the Royal Institution, in 1922, Professor H. H. Turner, the Savilian Professor of Astronomy in the University of Oxford, related the following story of how one last chance of being first in the field was lost to Adams on the day of the actual discovery of the planet. Early in the evening an assistant at the Cambridge Observatory turned the great telescope in the direction where Adams and Leverrier had said the planet would be found. The assistant was considerably younger than Challis, and his eyes were keener. Consequently, when he saw a neat round disk which did not appear to be a star he hurried to Challis and urged him to come quickly as he felt sure he had seen the planet.

Mrs Challis insisted upon his drinking a cup of tea, and the short delay was fatal. The sky, which had been clear, was now clouded over, and the last opportunity for being first in the field had vanished. That very night Dr Gallè saw the planet through the telescope at the Berlin Observatory, and it was announced that the credit of the discovery belonged to Leverrier.

As soon as Adams' claim to a share of the honours was put forward, angry discussions at once arose. The only interested person who remained undisturbed was Adams, who was quite satisfied that the planet had been discovered. This was all that mattered to him.

Later on, he met Leverrier at Sir John Herschel's home at Collingwood, and the two mathematicians became the best of friends. I was once shown an interesting photograph of himself which the French scientist presented to Adams with his signature and a few words of appreciation.

To-day, while all the world acknowledges the triumph of Leverrier, it also honours John Couch Adams.

In 1848 the Royal Society awarded Adams their highest honour, the Copley medal. In 1847, on the occasion of Queen Victoria's visit to Cambridge, a knighthood was offered to him, but he felt obliged to decline the honour. His fellow members of St John's College were not slow in showing their appreciation, and a sum of money was raised which provides the Adams Prize. This is awarded for the best essay on pure mathematics, astronomy, or other branch of natural philosophy. Perhaps one of my boy readers may win it one of these days.

In 1851, 1874, and 1876 Adams was President of the Royal Astronomical Society, and on the latter occasion he presented the gold medal of the Society to Leverrier. In 1870 Adams became director of the Cambridge Observatory. He is said to have been most helpful to students who were starting astronomical work and needed assistance.

Adams died in October 1892, and a medallion to his memory is to be seen near the memorial to Sir Isaac Newton in Westminster Abbey.

Professor Turner writes in *A Voyage in Space*:

> I scarcely think we English have done enough public honour to the part played by Adams; there is indeed a plaque of his head in Westminster Abbey, but in the centre of the courtyard of the Paris Observatory there is a fine statue of Leverrier, with head erect, pointing with his finger to a globe representing Neptune. "They order this matter better in France."

Shortly after the discovery of Neptune it was found that the planet was accompanied by a small satellite. It is about the size of our Moon and circles round the planet in a period of nearly six days. As though in the presence of royalty, it moves backward upon its course, following the example of the four moons of Uranus, Phoebe, one of the attendants of Saturn, and the eighth and ninth moons of Jupiter.

CHAPTER XIII

THE STORY OF THE COMETS

THE Sun in its journey through space is not only accompanied by its family of planets and their attendant satellites, but by numberless comets as well. Kepler once said that they were as numerous as fish in the sea. Comets look like bright, hazy stars with a trail of pale, wispy light. This is the tail of the comet, while the star is its head. The tail is often millions of miles in length when the comet draws near to pay its respects to the Sun, and if it be a large comet the head is thousands of miles in diameter.

When these objects were seen in the sky in olden times people were very much alarmed, fearing they might harm the Earth in some way. In *In the Days of the Comet* Mr Wells draws a lurid picture of what might happen if a comet should come too near to us. He pictures our Earth floating like a ball in the void when suddenly " the slender whirl of meteor " draws near to this planet, touches it, and " for three hours or more, no man nor beast nor bird nor any living thing that breathes the air stirred at all but lay still."

As a matter of fact, we actually passed through the train of a comet in 1861, and nothing happened. Moreover, scarcely anyone knew anything about it until it was all over. According to Sir Robert Ball, " we dashed into the comet or it dashed into us " on a Sunday evening in midsummer of 1861.

> We were not, it is true, in collision with its densest part; it was rather the end of the tail which we encountered. There were, fortunately, no very serious results. . . . Indeed, I have only

> heard of one calamity arising from the collision. A clergyman tells us that at midsummer he was always able in ordinary years to read his sermon at evening service without artificial light. On this particular occasion, however, the sky was overcast with a peculiar glow, while the ordinary light was so much interfered with that the sexton had to provide a pair of candles to enable him to get through the sermon. The expense of those candles was, I believe, the only loss to the Earth in consequence of its collision with the comet in 1861.

In reply to an inquiry as to the possibility of a collision between Halley's comet and the Earth in 1910, Sir Robert Ball replied :

> My dear Sir,
>
> A rhinoceros in full charge would not fear collision with a cobweb! And the Earth need not fear collision with a comet. In 1861 we passed through the tail of a comet, and no one knew anything about it at the time.
>
> For a hundred million years life has been continuous on the Earth, though we have been visited with at least five comets every year. If comets could ever have done the Earth any harm they would have done it long ago, and you and I would not be discussing comets or anything else.
>
> I hope this letter will give you the assurance you want. So far as I can learn, we may be in the tail of Halley's comet, about May 18th, and I sincerely hope we shall. I think Sir John Herschel said somewhere that the whole comet could be squeezed into a portmanteau.

In June 1921 the Earth narrowly escaped collision with a comet known as the Pons-Winnecke comet, after the name of the two astronomers who observed it ; it crossed the orbit of our planet a few days before the Earth arrived at the same point. Thus we were as safe as is a motor-car which crosses a railway track an hour or so before the express train dashes by. The poisonous effects of the gaseous tail of a comet are purely imaginary, for the density of the gas is so low that, as we have seen, the passage of the Earth through the tail passes unnoticed.

Some think that the tail of a comet is composed of small particles of matter which stream out from

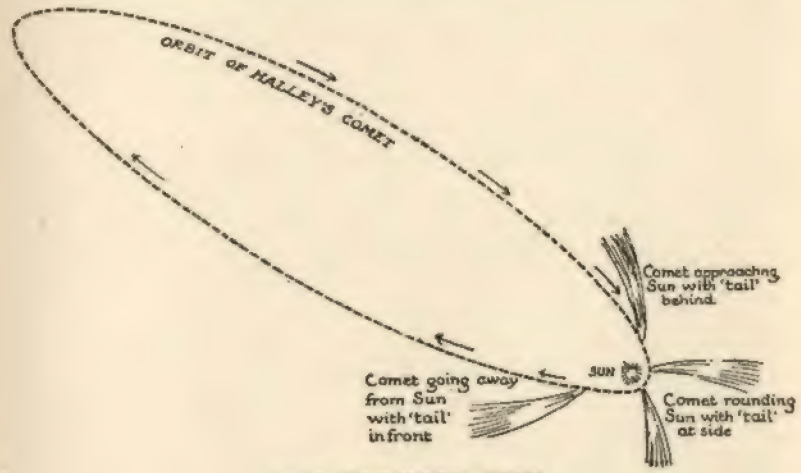
behind the nucleus or head of the comet, like jets of water from a hose; these particles are so widely separated from each other that stars can be seen through the spaces. Sir Robert Ball, however, in *In the High Heavens* holds that comets are composed of "a light volume of gas or vapour far less dense than the lightest cloud that ever floated in a summer sky."

As the comet approaches nearer to the Sun, the shining 'tail' enlarges to millions of miles in length, owing to the intense glow from the furnace-like Sun. The train is always directed away from the Sun, as if blown outward by some electrical force or light pressure, so that when the comet is receding from the Sun its tail goes before it.

Although, as we have seen, comets are composed of such flimsy material as to be comparatively harmless, yet we know that they are subject to the same great law of gravity which prevails on the planets. Should they fail to maintain a speed twenty thousand times as great as that of an express train when they approach the point when they are nearest to the Sun, it is *they* who are apt to come to grief. Drawn into the yawning depths of that glowing furnace the particles would vanish like a puff of smoke. Far away in space at its greatest distance from the Sun the comet can proceed at a more leisurely pace; the pull, or attractive power, of the Ruler of the Planetary System is considerably lessened there.

Instead of moving in a nearly circular ellipse like a planet a comet moves in a long and narrow ellipse, so that when at the far end of the loop, it may be ten or more times as far away from the Sun as when at the nearest part of its orbit. The curve it follows is called a parabola (from *para*, beside, *ballo*, I throw). When a boy throws a ball into the air to another boy at some distance away, the ball always describes a part of the beautiful curve known as a parabola.

There are little parabolas, such as that of a tennis-ball thrown by the hand and struck by the racket, and there are big parabolas, as when a bombardment takes place and a town is shelled. But the grandest of all parabolas are those described by a comet, and the Sun is nearly always very close to the turning-point. It is then that we are able to see the comet as it glows with reflected

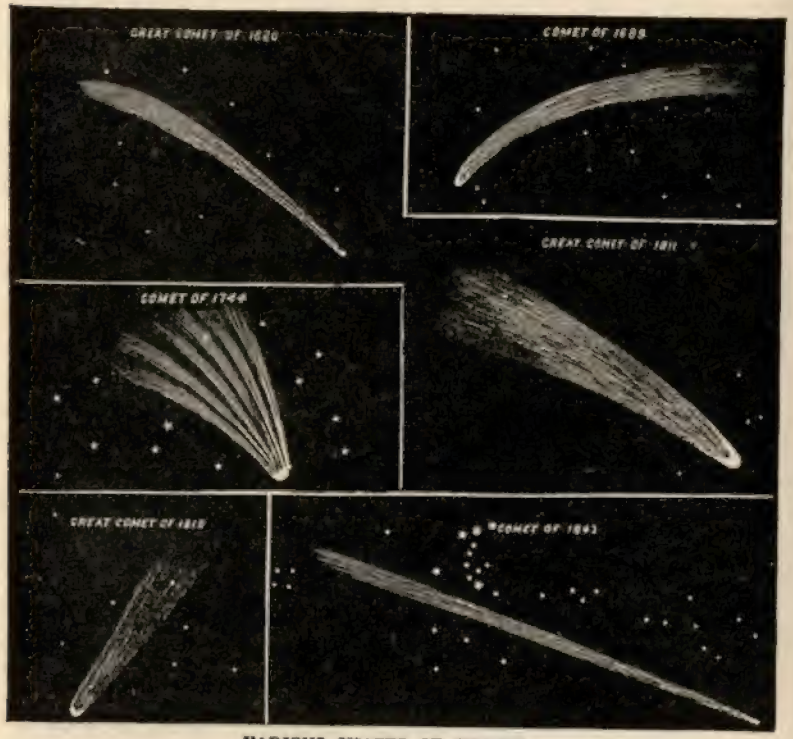


ORBIT OF HALLEY'S COMET

light from the Sun. As it retreats to the outer end of its orbit the comet grows dim and we lose sight of it for the time being. Moreover, the nucleus is all that remains, as the tail is only worn in the neighbourhood of the Sun.

It is impossible to recognize a comet by means of a photograph as it changes in appearance from hour to hour. At one moment it may be adorned with a plume-like tail curling over at the top like an ostrich feather; in a photograph taken half an hour later the tail may appear long and slender, or like smoke from a funnel, or resembling the spokes of a fan spread out wide open against the dark background of the sky; or the feather may appear bent, as if something had broken it in half.

If only a cinema operator had been ready with his camera in the eventful year 1908, when the Morehouse comet (named after its discoverer, Professor Morehouse, of Harvard University) surprised observers with its



VARIOUS SHAPES OF COMETS

'quick-change' performances during the period of one short night, what a revelation his film would have been. Yet so faint was the comet that it could not be seen without a telescope, and it was only discovered by a rare piece of good luck. Professor Morehouse was the guest of Professor Barnard at the time, and the latter placed at his friend's disposal for the night the photographic telescope presented to him a few years previously by

THE MOREHOUSE COMET, 1908 168
Photographed at Greenwich Observatory

COMET C, 1908
Photographed at Greenwich Observatory

STAR CLUSTER, CANES VENATICI 169

Photographed by Professor G. W. Ritchey with the 60-inch reflector at Mount Wilson Observatory

[*See p.* 251]

Miss Bruce.[1] All through that night Professor Morehouse took photographs of the heavens, little knowing the treasure-trove which awaited him. Next day when the plates were developed his surprise was great when he found the impress of a full-grown comet, tail and all, among the stars. A great number of photographs of the visitor were taken afterward, not only at Yerkes, but at Greenwich Observatory, and the appearance of the celestial wanderer varied more than most of its kindred.

As 1910 was drawing nigh, when the return of Halley's comet was expected, these photographs encouraged observers to hope that a wonderful series might again be obtained. This hope, however, was not fulfilled, and the views taken did not compare with the varied and peculiar effects illustrated in those of the Morehouse comet. When Halley's comet appeared on its previous visit in 1835, celestial photography was unknown, and the popular idea of its appearance was based upon the crude drawings made by the observers of that day.

The comet is named after the renowned astronomer Edmund Halley, who saw the wanderer in the year 1682. By means of careful calculations Halley found that the highway along which this comet travelled was the same as that of the comet which appeared in 1607, seventy-five years earlier, and others observed in 1531 and 1456. This interesting fact convinced him that the comets were one and the same, reappearing at intervals of seventy-five or seventy-six years, and he made a prediction which, as we know, was fulfilled. If the comet of 1682 is identical with that of 1607 and 1531, said he, then seventy-five years hence, in 1759, the comet will reappear. Halley expressed the hope that, if he was proved to be right, the world would remember that the prediction had been made by an Englishman.

[1] The lady after whom an asteroid, Bruccia, was named, and who offered a reward for its recovery when it was lost.

This celestial wanderer can be traced back to 1406, when a fine comet was observed during a period of great unrest. The Turks had taken Constantinople three years before, and were besieging Belgrade. The comet appeared to the imaginative people of those days as a sword reaching up to the Moon, from the west. At the same time, owing to an eclipse, the Moon appeared like a crescent—the Turkish emblem. This was regarded as an omen of the Turkish defeat which occurred shortly after.

Going back still farther, it is clear that the 'hairy star' which Queen Matilda of Flanders wove into the celebrated tapestry of Bayeux[1] was none other than our friend Halley's comet. In the tapestry the Normans are pointing at the wonderful sign in the heavens, which they took as foretelling the coming victory of William the Conqueror. On another part of the tapestry is the figure of a soldier who seems to be trying to keep Harold from toppling off his throne.

HALLEY'S COMET ON THE BAYEUX TAPESTRY

In China and Japan much attention was paid to fixing the exact paths of comets, since they were supposed to be celestial ambassadors going from one region of the sky to another, conveying warnings of coming disaster. This popular belief is expressed in Shakespeare's lines:

> When beggars die there are no comets seen,
> The Heavens themselves blaze forth the death of princes.

By means of Chinese records it has been possible to trace Halley's comet back to B.C. 240—May 15th.

[1] Commemorating the defeat of Harold, in 1066, at the battle of Hastings.

When the eventful year 1759 drew near great excitement prevailed among those who awaited the return of the comet which had been seen in 1682. Due allowance had to be made for the disturbing influence of the giant planets Jupiter and Saturn, for it is a well-known fact that at least fifty comets on their outward journey, after visiting the Sun, have as a result of passing too near Jupiter been compelled to alter their paths, and are now members of Jupiter's 'family' of comets.[1] Nevertheless, the calculations made by two French astronomers, Clairaut and Lalande, assisted by Madame Lepaute, proved to be correct, and to the amazement of the world the celestial wanderer hove in sight within the limits of the time set for its appearance.

The next visit was in 1835, when the comet was seen at the Observatory at Rome and at the Cape of Good Hope Observatory by Mr Maclear, the Astronomer Royal, and Sir John Herschel. It was not well placed for observation in northern latitudes, as was unfortunately the case again at its last return in 1910, when it provided a brilliant spectacle in southern skies.

During the latter part of the month of September 1909 I was the guest of Professor Barnard and his wife at Williams Bay, Wisconsin, and to this fortunate visit I owe the privilege of being among the first to see Halley's comet when it became visible through the great 40-inch lens of the Yerkes telescope. Once more the comet was approaching within the field of vision from our planet, and we knew, through the laborious calculations of Dr A. C. Crommelin and Dr P. H. Cowell, of the Greenwich Observatory, when and where it was to be expected in the sky.

On my arrival, September 17th, my first desire was to visit the dome and see the great telescope—the largest refractor in the world. Professor Barnard told me that

[1] Saturn has annexed a 'family' of three, Uranus two, and Halley's comet is a member of Neptune's family of four.

early that same morning Professor Burnham had detected a hazy-looking object, which proved to be the expected comet. Knowing that nothing would please me better than to see this for myself, Professor Barnard arranged that I should visit the dome at two o'clock the next morning with his niece, Miss Calvert.

THE "TIMES" BUILDING, NEW YORK

You can imagine my excitement as I made my way across the campus leading to the dome at the appointed hour. When we arrived we found all in darkness save for the glimmer of starlight seen through the opening toward which the tube of the great telescope pointed. The silence was only broken by the whirring of the clockwork which regulated the telescope, and the sound of an occasional brief word of direction from Professor Barnard to the operating assistant. There was something uncanny in the darkness and silence as we awaited the moment when we were to view the celestial wanderer after its long absence of seventy-five years. It was so pale and wan that when I first looked for it I could not see it, but as my eyes became accustomed to the dim light I finally detected a faint, misty film. Then I realized that I was actually looking at *the comet*. It was an experience I shall never forget.

During the month of May 1910 it was possible to see Halley's comet with the unaided eye in the morning sky. I was in New York City at the time, and I obtained permission from the assistant editor of the *New York Times* to watch for the comet each morning from the upper tower which surmounts the twenty-third story of the *Times* building.

At half-past two on the morning of May 1st I handed

the night watchman the pass admitting me to the tower. To reach this it was necessary to climb a spiral staircase after leaving the lift, or 'elevator' as it is called in the United States, at the twenty-third floor. The spiral led to a little balcony outside the tower, and there the watchman left me.

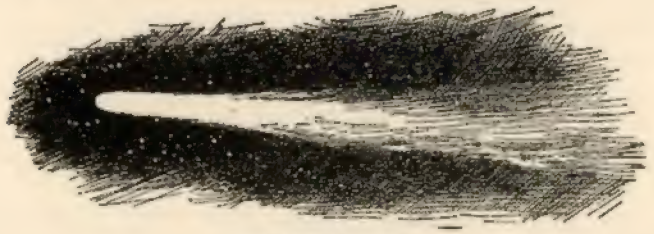
Beneath me lay the City, a mass of bright lights intermingled with dark shadows and in the distance a deep gloom. Farther away, due east, were the lamps outlining Queensboro' Bridge, and still farther away, in the south-east, could be traced more dimly the outline of Brooklyn Bridge, lit up by occasional flashes from the lurid glare of the gasworks. Every now and then flashes of blue light from the neighbourhood of the railroad tracks resembled streaks of lightning. It was all very weird at that great height, and it was also disappointing, because for three mornings in succession not a trace of the comet was to be seen.

But on the morning of May 4th my vigil was rewarded. I did not reach the tower until 3 A.M., and it was so chilly that the janitor advised me to remain inside and watch for the comet through one of the windows. Needless to say, I did not follow his advice. I walked out on the narrow balcony, and imagine my delight when on looking north-east I saw the comet in all its glory, with a train some twenty degrees in length.[1] Calling to the janitor, I told him to let the assistant editor and the night staff of the *Times* know that the comet was visible.

When the assistant editor came up to the tower, he lent me his field-glass, which enabled me to see an extension of the train, and spurts of light, like tiny waves, seemed to ripple out from the nucleus of the comet to a distance of two or three degrees. The light of the comet faded rapidly, and at twenty minutes to four, looking

[1] A degree is one-fifth the distance separating the Pointers, Alpha and Beta, in the group of stars Ursa Major, known as the Plough in England, and as the Great Dipper in America. From Alpha to Delta is ten degrees.

downward at the horizon, I was startled by seeing what appeared to be a streak of flame. As this rose higher I saw that it was the crescent Moon emerging from the low-lying mists. The comet now appeared like a bright star with a slender stream of silvery grey mist trailing a few degrees after it, but in the rapidly brightening sky at the approach of dawn it gradually faded from view, until at four o'clock it was invisible.



HALLEY'S COMET

Another view on May 12th was the best that New York had of the comet, and I was told that eighty-five boys and girls on the east side of the City "howled with delight" when they caught their first glimpse of it. "I wouldn't have missed it for worlds," said a boy of twelve, one of the keenest of the young astronomers.

It appears that a teacher in one of the public schools had announced that he would show the comet to fifty boys if they would meet him opposite the school at 2.30 on the eventful morning. To his surprise a crowd assembled nearly double that number, and, moreover, it included a number of girls.

Heading a procession, the teacher started for the Park, and as they marched through the streets the enthusiasm of the boys and girls mounted to boiling-over point. As the procession passed down Fifth Avenue windows opened and heads popped out of the hundred-thousand-dollar mansions.

So impatient were the youngsters at the slow move-

ments of the policemen who opened the gates of the Belvidere Observatory at Central Park that some climbed the walls and scrambled up and over. In fifteen seconds the 85 youthful astronomers had each discovered a separate and distinct comet of his own—but minus tail. Then, when they found they had been looking at stars the teacher pointed out the actual comet, and gave his audience an account of its nature and history. Then, when daylight was breaking he led his following back to the school to dismiss them.

Some of the boys were too full of excitement to go to bed when they returned to their homes, so they sat on the doorsteps discussing the comet. All the children were punctual at school the next morning. (What a memory this will be for them at the next return of Halley's comet seventy-five years later !)

My first glimpse of the comet on that morning from the tower was at ten minutes past three. At first it was but a faint white streak in the sky. A minute or so later Venus came into view, gaining in brilliancy as it rose above the mists near the horizon. At twenty-five minutes past three the train of the comet was twenty degrees in length, and by half-past three it extended for a distance of thirty-five degrees, or seven times the distance between the 'Pointers' Alpha and Beta in Ursa Major. Instead of being long and slender, as it appeared on the morning of May 4th, it was now spread out like a partly opened fan, its greatest width at the extreme end being about five degrees. The nucleus resembled a golden globe wrapped in folds of gauze, but it became more clearly defined each moment until finally it glowed with the brilliancy of a star of the second magnitude.

By half-past three, as the stars began to fade in the light of the approaching dawn, the train of the comet was still visible extending to a distance of twenty degrees. Then it gradually faded from view, just as Antares, the

star which marks the heart of the celestial Scorpion, peeped over the edge of the south-eastern horizon as though wishing to share with us a glimpse of the comet. At twenty minutes past four the comet was invisible, and Venus was left alone in her glory to greet the rising Sun.

The comet was barely visible for the next five mornings, which brings us to May 18th, when the Earth, it was expected, was to plunge through the *débris* forming the train of the comet at 10.50 P.M. According to the programme worked out by the astronomers, the comet would no longer be visible in the morning sky. From 10.30 until midnight the little balcony of the *Times* tower was crowded to its utmost capacity with people expecting they knew not what. Looking down at the city below we could see comet parties in progress on the roof-gardens of the larger hotels. After midnight the party on the *Times* balcony had diminished to two—myself and a young lady who was to share in the good fortune which awaited me.

Professor Jacoby of Columbia University had announced that it would be useless to sit up till 3 A.M. watching for the comet in the eastern sky, as it was now due in the west. However, I had noticed in the *Times* for May 18th a note from Professor Barnard of the Yerkes Observatory stating that he had seen in the eastern sky some straggling streamers indicating the comet. For the first time since May 1st I had missed on that morning of May 18th my vigil at the *Times* tower, so I was determined to be on guard on the morning of the 19th, despite the fact that one of the reporters of the *Times* informed me that Professor Jacoby had told him that he was going to enjoy a good night's rest.

At half-past two we were rewarded for our long and patient wait, and I told my companion to look in the direction of the eastern sky. As the Moon set we saw a band of light one hundred degrees in length and about

ten degrees in width becoming visible. Throughout its length it had a brilliancy equal to that of the Milky Way, near which it terminated. The direction of this band of light was very nearly that of the path on which the comet had last been seen, and I was sure that it was the outer boundary of its train. Beneath this streamer, and apparently resting along the south-eastern horizon, was a fainter band which was not as clearly visible as the other, and it merged into the mists of the horizon. I made a sketch of these streamers, and Professor E. E. Barnard remarked with regard to it: "Miss Mary Proctor has shown me a sketch which she made on the morning of May 19th, 1910. Her sketch closely resembles my drawing of the same date, especially in showing the fainter portions of the trail which extend to the south-east horizon. I have seen no other picture of this phenomenon, nor indeed any mention of it elsewhere." [1]

At a quarter-past three the streamers had faded from view, and a pale blue light illumined the north-eastern sky above the purplish-grey mist that bordered the horizon. The stars in the Great Dipper, and the constellation of Cassiopeia, were still shining brightly. Vega was almost directly over the flagstaff on the tower, and low down, partially immersed in pale blue mist, was the radiant Algol, named also 'Demon Eye' by the Arabians because of its ever-changing light. The grey outlines of the skyscrapers stood out in strong relief against the soft blue and pink skies that announced the approach of dawn. The softly blended tints made New York City appear as beautiful as a painting by Turner, but at half-past four, with the appearance of bright red streaks in the east, the scene faded, the stars vanished, and rosy-fingered dawn drew aside the curtains of day. A sea of burnished hue, glistening on the shores of an island of grey mist was revealed. Above this rose the first gleam of gold, steadily rising higher like an inverted globe, until

[1] See *Astronomische Nachrichten*, Nr. 4431, Band 185.

finally the Sun shone full-orbed and brilliant in the morning sky. My long watch from 10.30 P.M. the night before until 4.30 A.M. on May 19th, 1910, was ended; it seemed to me to have been well worth while.

Between my first view of Halley's comet in September 1909 and my final view in May 1910 I was fortunate in seeing another of our celestial visitors. During the second week of January 1910 I left New York for a lecture tour in England, going by way of Glasgow on the S.S. *Caledonia*. The morning after we had reached port I left for Edinburgh, and in a newspaper which I read on the train I learned for the first time of the appearance of the Daylight comet, which was mistaken at first by many for Halley's comet.

Next day, January 21st, I called at the Royal Observatory, and Sir Frank Dyson, then the Astronomer Royal for Scotland, invited me to return that evening and see the comet through the great telescope. Unfortunately, I missed the opportunity through losing my way, and I climbed to the smaller observatory on the Calton Hill only to be told by the gatekeeper that no one was at the Observatory.

This was discouraging, but it was too late to make another attempt to get to the big observatory, where I knew a cordial welcome awaited me, so I made the best of the situation. Facing the western sky, I patiently waited till the comet should make its appearance at five o'clock, as announced. A heavy bank of clouds, however, was not reassuring, although very picturesque, glowing with ruddy hues. Clouds of smoke drifted from the factories toward the Castle, which crowns the loftier hill near by. Meanwhile, Venus had become visible, gaining in brilliancy as the twilight faded. It served as a guide to those who were looking for the comet, for we had been told that it would be seen to the right of Venus.

A party of six observers had joined me, and while we

HALLEY'S COMET SEEN FROM PARIS
Evelyn Paul

stood shivering and expectant an elderly gentleman informed us that he had seen Donati's comet of 1858. Another, while at the Cape of Good Hope in 1882, had seen the Daylight comet of that year.

A few moments after five the comet became visible, a beautiful sight glimmering just above the horizon. Its head gleamed like a bright star adorned with a plume-like train curving in the direction of Venus. The length of the train was about three degrees, or not quite the distance separating the Pointers Alpha and Beta in the group of stars known as Ursa Major. The comet looked like a feather drifting in the sky, but by half-past five it was hidden behind the low-lying mists above the horizon and could be seen no more that night.

The next evening I arrived at Newcastle about five o'clock; just in time, as I hoped, to get a glimpse of the comet. Hastening to my hotel I scarcely waited to sign my name on the register before requesting an attendant to take me to the topmost floor, where I could look out of a window facing west. Taking me, doubtless, for a harmless lunatic, 'Buttons' escorted me in the lift, alas! only to the fourth floor. How I longed to be on one of the skyscrapers in New York!

However, I got a glimpse of the comet just hovering over the chimney of a factory, from which unfortunately wreaths of black smoke made the outlines of the comet appear very indistinct. I could see that the train had increased in length to five degrees. 'Buttons' was extremely interested, and wanted to know where the comet had come from, and whether it was going to hit the Earth, but I told him it was perfectly harmless. "Seen the comic," I heard him announce, as I went into the dining-room a little later, "and the lady says it won't do us no harm."

The last view I obtained of the comet was on the evening of January 28th, and this time I had arranged to watch for it from the Town Moor at Newcastle, a

wide, open expanse with a clear view of the western sky. The evening was bitterly cold and the ground covered with snow, so that it required the warmth of enthusiasm to endure cheerfully the effects of the chilly blasts which swept across the heath. To make matters worse, they came directly from the west, so that it was necessary to face them in watching for the comet. A few stragglers on their way homeward across the moor would stop for a moment and look up at the sky, and one or two were quite satisfied that Venus was the comet. I was feeling entirely too frozen to enlighten them on the subject.

By walking swiftly to and fro I managed to keep my chilly vigil. When I turned eastward, I saw the Moon like a ball of fire slowly emerging from a bank of dark clouds near the horizon. Turning westward again I was rewarded at last by a view of the comet half-way between Venus and the horizon. Its train was now three times as long as when I first saw it, or three times the distance between the Pointers. As before, it spread out like a plume, curving over in the direction of Venus, and it looked very much like pictures I have seen of Donati's famous comet of 1858. The outer edge of the plume was clearly defined, but the inner edge was feathery in appearance.

Despite the intense cold during the next half-hour I watched the outline of the comet as it gradually became clearer against the slowly darkening sky. Then the comet faded from view as the Moon rose higher and higher in the heavens, its light concealing that of the comet. With regret and many a backward glance at its fast-fading outline, I retraced my steps across the bleak moor to the hotel. The Moon was now radiant in glory, its reflected light giving the snow a fairy-like aspect, yet it seemed the irony of Fate that this same moonlight should eclipse the glory of the Daylight comet.

CHAPTER XIV

METEORITES AND SHOOTING STARS

This majestical roof, fretted with golden fire.
SHAKESPEARE

IN the year 1886 a meteorite, known as the Brenham, fell on a prairie in Kansas; it had exploded and scattered over an area more than a mile in length. The fragments became only partly covered by the prairie soil and when the farmers struck them with their mowing-machines or other farm implements they wondered whence came these heavy ' rocks ' in a region where even smaller stones were scarce.

Until the ranchmen learned that they were meteorites which formerly roamed in the sky, they were not treated with the least respect. One of the thirty fragments found was being used to hold down a cellar door. It was what might be termed ' hefty,' for it weighed seventy-five pounds. Another was in use as a weight on the cover of a rain barrel, and a larger but lighter fifty-two pound lump served as a weight on a haystack. The total weight of all the known fragments of this meteorite is about two thousand pounds. The largest piece weighs over four hundred pounds, and the smallest merely an ounce or two.

When the ranchmen learned that the ' chunks of iron ' had fallen from the sky they were greatly surprised. They were still more surprised when they heard that the ' chunks ' were to be placed in the Museum of Natural History in New York. They are now to be seen in the hall in which is displayed the famous Willamette meteorite,

the largest ever found in the United States. It weighs 15.6 tons; its length is ten feet; its height is six feet, and it is four feet three inches thick. It has holes in its surface so deep that, as you may see, a boy or a girl could sit comfortably in several of its hollows.

These hollows were caused by intense heat. When the great mass, hurrying along through space at the rate of

THE WILLAMETTE METEORITE

From a photograph, by permission of the American Museum of Natural History

about twenty-five miles a second, plunged into the atmosphere surrounding our planet, it came into collision with the myriad particles floating in the air. Lord Kelvin has shown that a body moving through the air with a speed exceeding ten miles a second becomes heated to the same degree that would melt metals. During a meteorite's flight, therefore, its surface becomes intensely hot, and the portions melted are swept off by the rush of air, condensing as they cool to form the train which glows like summer lightning for a few seconds and then fades from view. The particles, if any are left, sink to earth, awaiting discovery by lucky finders.

The Willamette meteorite was found in the autumn of 1902 in a forest about nineteen miles south of Portland by a former Welsh miner, Ellis Hughes, on land belonging

to the Portland Land Company. He thought at first that he had discovered an iron-mine, but on digging the earth away from it saw that the mass was detached and realized that he had unearthed a meteorite. To gain possession he constructed a low wooden truck, on to which he managed to overturn the 15-ton mass, and then, with no other motive power than an old horse, windlassing a rope round a capstan as a winch which had to be moved and reanchored as the truck with its load was drawn up to it, he and his 15-year old son, working so quietly during the winter that not even the nearest neighbour suspected what they were doing, dragged the mass three-quarters of a mile on to his own land.

When the news of the 'find' was noised abroad, the Portland Land Company naturally brought a suit for possession, and Hughes' lawyer pleaded that the meteorite was not 'real estate' but 'discarded personal property,' belonging to whoever might find it. In support of this he claimed that it was an 'Indian relic,' known and revered from time immemorial by the Siwash Indians, and he called as a witness a very old Siwash Indian—almost the last of his race—who testified that the mass of iron had long been known to members of his tribe, who attributed to it magic virtue. As a youth, he said, he had been conducted to it by one of the medicine men and informed that if arrows were dipped in the water which collected in its hollows they would always wing true to the heart of the game shot at. However, the judge ruled that the meteorite went with the land, and issued an order giving possession of it to the Portland Land Company.[1]

This incident recalls the following story told by Sir Robert Ball. A farmer once rented his farm to a tenant. One evening the latter saw a bright light flash across the sky, and something fall on the ground.

[1] This account is taken substantially from the London *Daily Chronicle*.

Next morning he went to the spot and found a meteorite. He took it home and showed it to his friends. The farmer hearing of this 'find' went to the tenant, and claimed the meteorite as his, because when the lease was made out it contained a clause to the effect that all minerals found on the farm should be his.

"But the meteorite was not on the farm when the lease was made out," argued the tenant.

Then the farmer claimed it as flying game, but the tenant pointed out that it had neither wings nor feathers. While the dispute was going on, however, the Customs officers came in and seized the meteorite because it had come from a foreign country and no duty had been paid upon it.

Later, the Willamette meteorite was purchased by Mrs William E. Dodge, and presented to the Museum, where it resides.

There it may be seen, dumb as to its past, like the mighty Sphinx. It has been weighed, measured, and tested by chemical analysis, but where it originally came from can never be known. Perhaps it was hurled out of a volcano on the Moon, or it may have been connected with a comet, for it has been proved that comets and meteors are often closely related, as we shall see later.

The sudden way these objects blaze out and reveal their presence makes them very attractive. One fine evening you are walking, let us say, across a park, with a clear, open expanse of sky overhead. Suddenly a bright light flashes out and as mysteriously vanishes.

"Ah! a shooting star!" you doubtless exclaim, and if you are anxious to be in the limelight, you hurry off a letter to the editor of your favourite newspaper, telling that at such a time, on such an evening, you saw a magnificent meteor, near a certain bright star, so that readers of the newspaper may know where it was seen, by looking at the position of the star in a star atlas.

However, it is just as well to make quite sure that you have seen a meteor before writing.

Some years ago the editor of *The Times* received the following message:

> A large meteor was seen to-night at 9.27 moving very slowly along the northern horizon, from west to east, at an altitude of about eight degrees. It was at least three times as bright as Venus, remaining visible for nearly five minutes, moving slower than any hitherto observed. I should be glad to receive observations made at more favourable stations.

A reply to this letter was as follows:

> The large 'meteor' seen on Monday at 9.27, three times as brilliant as Venus, and moving from west to east, was a fire balloon sent up shortly after eight o'clock from the Eton and Middlesex cricket ground, as a finale to some athletic sports which had taken place during the afternoon!

There are many superstitions which still cling to shooting stars, such as the custom of 'wishing' before the star fades from view. The Arabs thought that shooting stars are fiery stones hurled at the heads of evil spirits who venture too near the abode of the immortals. When these spirits are caught in the act of eavesdropping a well-directed meteor sends them crashing headlong, their blazing trail serving as a warning to evil-doers on Earth.

This legend can be found in the Koran, and the poet Moore refers to it, in "Paradise and the Peri":

> Fleeter than the starry brands
> Flung at night from angel hands
> At those dark and daring sprites,
> Who would climb th' empyreal heights.

Many quaint stories are told of the fear inspired by the sudden blaze of light seen in the sky. For instance, a Hindu saw a meteorite fall in a jungle, but was so frightened by the noise of its falling, and the danger he believed he had so narrowly escaped, that he could tell little of what he had seen. He was only sure of one thing;

that was, that the meteorite had hunted him for two hours through the jungle before it fell to earth!

In East Africa a meteor fell at Wanika on March 6th, 1853. The natives looked upon it as a god, anointed it with oil, covered it with garments sewn with pearls, and placed it in a temple, where it received special honours. We learn from Virgil and other Latin writers that meteorites were worshipped by the ancients.

A meteor which fell with a deafening crash in Hungary on September 7th, 1514, was looked upon as a messenger of the gods. A temple was erected within which it was fastened by a chain so that it could not vanish as mysteriously as it had come. A meteorite which fell in Artois, France, was also fastened with a chain of iron, because it was said to disappear on certain nights each year.

Old chronicles, diaries, and parish registers contain many quaint records of 'stones from the sky.' One of the stones, we are told, fell at Barolkin Green (1½ miles from Hatford) in 1628 and was dug up by Mistress Green. It broke, one piece weighing 19½ lb. and another 5 lb. In 1738 a great meteor was seen to fall at Reading. "It was that," states the chronicler, "which some naturalists call Draco Volans, or Flying Dragon—seen in Devonshire, Berkshire, and Derbyshire."

But the most thrilling story is dated 1366, when "there was a movement of the stars such as men never before saw or heard of; and those who saw it were filled with such great fear and dismay that they were astounded, imagining that they were struck dead, and that the end of the world had come."

If the display was anything like the great November shower of meteors of 1833 the account is not as exaggerated as it may appear to be. To begin the story we must look back nearly a thousand years, to the record of the death of a Moorish king in the year 902, of which event an old chronicler relates:

> That night there were seen, as it were lances, an infinite number of stars, which scattered themselves like rain to right and left, and that year was called the *Year of the Stars*.

Since then these displays have occurred every thirty-three years, and that of the 13th of November, 1833, must have been marvellous. We are told that the meteors fell as thickly as snowflakes, and a South Carolina planter gave the following impressive account of the terror of his negroes:

> I was suddenly awakened by the most distressing cries that ever fell on my ears. Shrieks of horror and cries for mercy I could hear from most of the negroes of the three plantations, amounting in all to about six or eight hundred. While earnestly listening for the cause, I heard a faint noise near the door, and it was some one calling my name. I arose, and taking my sword, stood at the door.
>
> At this moment I heard the same voice still beseeching me to rise, assuring me that the world was on fire. I then opened the door, and it is difficult to say which excited me most, the awfulness of the scene or the distressed cries of the Negroes. Upward of a hundred lay prostrate on the ground, some speechless and some giving utterance to the bitterest cries. With hands upraised, they implored God to save the world and them. The scene was truly awful, for never did rain fall much thicker than the meteors fell towards the earth—east, west, north and south, it was the same.

In 1866, at the next return of the meteors, Europe seemed to be the main target of the fiery darts, and dense crowds of meteors seemed to fill the sky, all radiating from the sickle-shaped group of stars in the constellation of Leo, the Lion. That is why these displays are usually referred to as the Leonids. To quote Sir Robert Ball's account given in *The Story of the Heavens*:

> On the night between November 13th and 14th, 1866, we plunged into the middle of the shoal. The night was fine; the moon was absent. The meteors were distinguished not only by their enormous multitude, but by their intrinsic magnificence. I shall never forget that night. On the memorable evening I was engaged in my usual duty at that time of observing nebulae with

Lord Rosse's great reflecting telescope. I was, of course, aware that a shower of meteors had been predicted, but nothing that I had heard prepared me for the splendid spectacle so soon to be unfolded.

It was about ten o'clock at night when an exclamation from an attendant by my side made me look up from the telescope, just in time to see a fine meteor dash across the sky. It was presently followed by another and then again by others in twos and in threes, which showed that the prediction of a great shower was likely to be verified. At this time the Earl of Rosse (then Lord Oxmantown) joined me at the telescope, and after a brief interval, we decided to cease our observations and ascend to the wall of the great telescope from whence a clear view of the whole hemisphere of the heavens could be obtained. There, for the next two or three hours, we witnessed a spectacle which can never fade from my memory. The shooting stars gradually increased in number until sometimes several were seen at once. Sometimes they swept over our heads, sometimes to the right, sometimes to the left, but they all radiated from the east . . . . It would be impossible to say how many thousands of meteors were seen, each one of which was bright enough to have elicited a note of admiration on any ordinary night.

This description and others written by different observers naturally aroused interest in the expected display of 1899. Sir Robert Ball was bombarded with letters and callers who were anxious to know exactly the hour and date of the Leonid shower. A maid who opened the door to inquirers on the morning of November 13th answered the usual question as to which was the best time to watch for the meteors by telling the callers to watch all night. As the display could not begin until the stars of the constellation Leo made their appearance (about 1 A.M.), the people who watched all night had no reason to be grateful for this direction.

A story is told of a college porter at Cambridge University who was asked to keep a look-out for the shooting stars and report to a festive party indoors as soon as the display began. When questioned at about 1 A.M. he replied: "They had none of them shot yet, but some of them looked as if they were just going to."

My own experience in 1899 was not encouraging. I

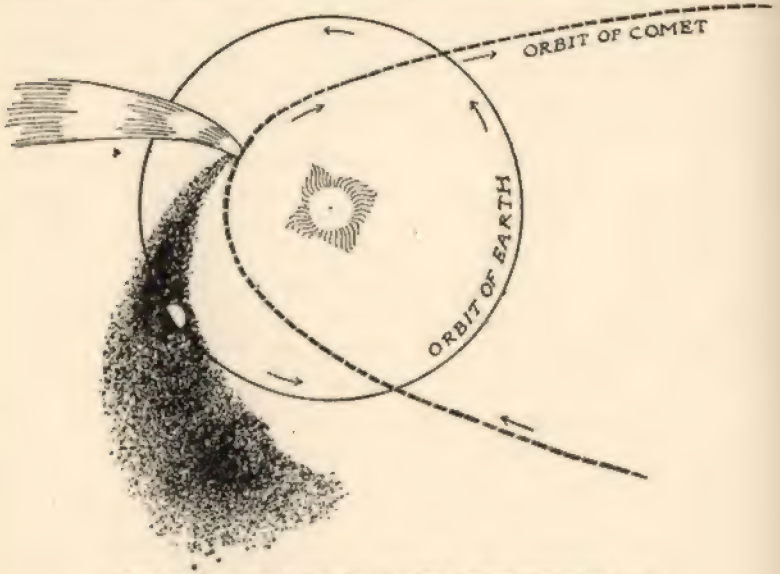
was in New York at the time, and had made arrangements with two of my friends to watch the display from the roof of an apartment house.

It was a bitterly cold night, but we bravely remained at our post and observed from one o'clock until dawn. Our record though beginning, "Sky clear," soon went on: "Clouds drifting—small clouds—bands of clouds—misty, streaky clouds." We saw forty-four meteors in all; meteors with long trains, short trains, small trains, or scarcely any trains at all. Of the number, six were not Leonids, so that our 'bag' amounted to thirty-eight Leonids and six intruders.

It was little comfort after our weary vigil when we were told that we might possibly have better luck next year. However, 1900 came and on November 13th we watched again, but the result was even less encouraging. The next display is expected in 1932, when if our planet and the procession of meteors reach at the same time the point upon the Earth's orbit where they meet we shall see something worth watching and waiting for.

Professor Adams, who, you will remember, was so successful in tracking Neptune, later succeeded through some other wonderful calculations in tracing the origin of the November meteors to a comet discovered in 1866 and known as Tempel's because of the usual custom of naming a comet after its discoverer. This comet travels along the path of the meteors in the densest part of the swarm composed of the millions of particles from the comet's train when in times past it approached the Sun. The comet sweeps round the Sun once in every thirty-three years, and as it passes away into space it leaves these particles scattered along its course. Each time it draws near to pay its respects to its mighty ruler, the Sun, it sends out another train. Thus countless new trains have been formed and left behind, with the result that the track is strewn with the particles. This pathway is a long, narrow oval, and every year between November

13th and 14th we may expect to see a few of the Leonids. The grand display, however, is only seen when the track of our planet is crossed by the densest part of the swarm of meteors. The track is millions of miles in length and about one hundred thousand miles in width, and the



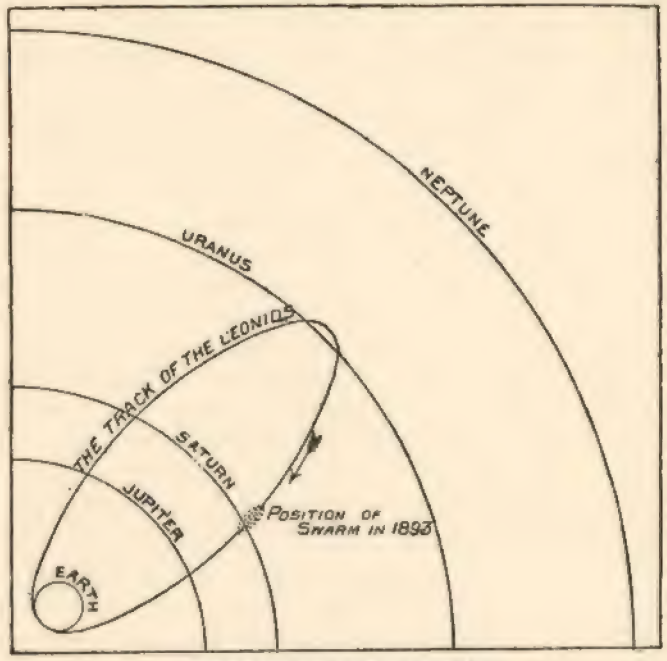
THE EARTH IN TRAIL OF DÉBRIS FROM COMET'S TAIL

particles are probably some few miles apart, each journeying upon its own ellipse.

While they formed part of the comet's train in its progress round the Sun the particles were close together, but as the comet passed into the great mysterious distance beyond the Solar System, they were left to take care of themselves, although their course was largely shaped by the Sun.

They pass through the zone of asteroids, and a close approach to Jupiter or Saturn would mean a slight delay; possibly some are drawn into the atmosphere surrounding those planets, to vanish in a streak of glory. On the

millions that escape this fate the delays have the same effect that one notices on a circular race-track. Eight or ten boys start together, let us say, from the selected post in front of the grand stand. These boys may possibly



THE ORBIT OF THE LEONIDS

From "In the High Heavens," by Sir Robert Ball

keep well together at first, but after a while one wearies and another goes more slowly, with the result that before the race is finished the last runner is so far behind the one who is leading that the latter is almost at his heels. And so the runners become scattered round the course, which is exactly what happens to the particles which provide the display known as the November showers of meteors. They require over two years to pass the terrestrial grand stand from which we are watching

them, so that if we miss them when the comet in the densest part of the shoal passes by there is always a chance of getting a view of the stragglers at the tail of the procession. That is why we were advised to watch again in 1900 after our dismal failure in 1899.

Thus we see how the meteors forming part of the train of a comet have been adopted by the Sun, and have become members of his family just as surely as the planets Jupiter, Saturn, Mercury, or Mars. Like the planets they are compelled to move in elliptic paths, their speed depending upon their distance from their ruler. When near the Sun they race along at the rate of hundreds of miles a second, but their speed is greatly reduced as they approach the outermost limit of their long, oval-shaped course. As they approach the neighbourhood of the Earth they are perfectly safe as long as they keep out of reach of the blanket of air which surrounds our planet, but should they venture too near they are doomed to suffer the fate which overcame the fly whose curiosity led him into the spider's web. Plunging downward at a terrific speed, one hundred times that of a rifle bullet, they become intensely heated by friction with the particles in our atmosphere. This, as we have seen, nearly always reduces them to vapour, and we are made aware of their presence only at the moment when they vanish from the celestial stage.

If anything is left of the meteorite or shooting star, whichever it may happen to be, it is usually only particles which fall upon our planet in the form of fine dust. This has been sifted from snow on the tops of high mountains. Meteoric stones have been brought up by dredges from the bottom of the sea or found in deserts or prairie regions, but they rarely fall in densely populated districts. Otherwise these celestial bullets would make bullet-proof houses and metal umbrellas more or less a necessity.

As a matter of fact in only one instance is it suspected that a meteorite actually reached the Earth's surface

during the progress of a shower. This was on November 27th, 1885, when a piece of iron, presumably from a comet known as Biela's (from the name of the Austrian officer who discovered it), fell at Mazapil, Mexico.

This small comet was discovered in 1826, and its journey through space occupies a period of 6¾ years. In 1832, said the astronomers, it would cross the orbit of the Earth. This announcement caused a 'comet scare' in Southern France, until the French Professor Arago assured the fearful that there was no need for alarm. At the return of the comet in 1846 it was seen that it had split in two, the halves sailing along side by side separated by a distance of about 165,000 miles. Upon their next visit, in August 1852, the twins were farther apart, and on November 27th, 1872, just as the Earth was crossing the track of the comet, but some millions of miles from the point which the comet ought to have reached, there was a wonderful display of meteors. Similar displays have since been seen, but whether the meteors are the remains of the comet or other small bodies following it is not known. Anyway, after mid-November we may always look for a few meteors from the direction of the constellation Andromeda; they are usually referred to as the Bielids.

During the month of August fine meteoric displays may be expected between the tenth and eleventh. They are sometimes called the 'tears of St Lawrence,' as the 10th of August is dedicated to the memory of that saint, but they are more generally known as the Perseids, because they come from a point in the group of stars known as the constellation Perseus. The Bielids can be seen any time of the night, as the constellation Andromeda, from which they radiate, is always above the horizon. The Perseids, on the contrary, are best seen during the month of August, as the constellation Perseus, from which they radiate, rises north-east early in the evening of that month, and is above the horizon

nearly all night. Look for it during the month of May, and you will find that it is north-west early in the evening, and approaching the horizon, below which it soon disappears.[1]

Meteorites are generally divided into three classes, according to their mineral composition. Firstly, 'siderites' or stone meteorites, which consist of a mixture of iron and nickel; secondly, 'siderolites,' or iron-stone meteorites, which are formed of a nickel iron sponge or mesh, containing stony matter in the hollows; and, thirdly, 'aerolites,' or stone meteorites, which are made up mainly of stony matter, but almost always contain grains of nickel iron scattered through their mass. We may know them by what looks like a thumb-mark, as though some one had picked up a stone while it was still hot and its surface soft. Should you come across specimens such as these in your rambles, you may find that they are what the people of old termed 'stones from the sky.'

For all we know, some of the dust which sifts in through the window and settles on tables and chairs may be particles which once drifted through space, but whether this be so or not matters little to the careful housemaid next day. It is no use telling her that it may be dust which has come from the sky, for she would doubtless reply that "There's a place for everything, and everything should be in its place."

[1] Andromeda is a circumpolar constellation, that is, it appears to circle round the Pole Star; it is within 40 degrees of the North Pole. It is therefore always visible at night in England and the United States. Perseus is farther away from the Pole Star, and is only visible part of the night in consequence.

CHAPTER XV

THE SUN'S JOURNEY THROUGH SPACE

TO make the wondrous journey through space we must engage our passage on one of the planets, and this has already been arranged, since we are passengers on planet Earth. The Sun is the flagship which controls the movements of its fleet of planets and their attendant satellites, comets, and meteors down to the minutest atom, and so as to keep a close watch upon its celestial company it turns round once in a period of about twenty-seven days. It is at the same time advancing onward across the Ocean of Space with a speed of twelve miles a second, fortunately for us through a region clear of stars.

The nearest star visible to the unaided eye,[1] Alpha in the constellation Centaur, is so remote that if a railway could be run to it from the shores of our planet a train going at the rate of a mile a minute, without stoppages, would require about fifty million years to complete the journey. The length of the track would be about twenty-five million millions of miles, so that the fare, even at the reduced rate of one penny per hundred miles, would be very costly. In one of his interesting lectures Sir Robert Ball tells us that five thousand carts loaded with golden sovereigns would be required to convey the price of the ticket to the railway station. The clerk would require a considerable time to count it, a few hundred years or so, but we will suppose that the owner of the track is so pleased at the idea of having a passenger that

[1] The faint star Proxima Centauri is actually the nearest star; it is at a distance of twenty-four million million miles, according to Dr J. H. Jeans.

he tells the clerk not to bother about counting the money.

Our wealthy tourist takes his seat in the carriage, when it occurs to him to ask the guard : " At what rate are we to travel ? "

" Sixty miles an hour, sir, without stoppages," is the answer.

" And when shall we reach Alpha Centauri ? " [1]

" In 50,663,060 years, sir."

It is too late for the surprised passenger to change his mind, for the signal has been given and before he can recover from the shock the train steams out of the station on the journey which is to last for those many millions of years.

If you will write down ' 25 ' with twelve cyphers after it, you will get the distance expressed in miles, thus : 25,000,000,000,000. And if you have a vivid imagination you will see that the ' 25 ' represents the engine and the twelve cyphers the carriages for the passengers.

Nowadays the railway is considered slow, but if the tourist engages an aeroplane travelling at the rate of 144 miles an hour, he would be twenty-two million years crossing the vast abyss.

Even a ray of starlight, which travels at the rate of 186,325 miles per second, is more than four years on its way from Alpha Centauri before it alights upon our little world. Yes, indeed, there is little room to fear that the Sun will come into collision with this star.

Turning a telescope in the direction of Alpha Centauri, we find it is a double star. I saw it for the first time through the telescope at the Sydney Observatory, N.S.W., and noted that each of the twins is orange in hue. Astronomers say that each is about the same mass and size as the Sun. Our Sun viewed from a planet circling round the twins would appear as Alpha Centauri does to us, merely as a bright point. The giant Jupiter

[1] Alpha in the constellation Centaur.

would seem but a speck of light near by, requiring a telescope with an opening of 250 inches to reveal it. Our tiny world would be quite invisible, so that the Centaurites, if we can imagine inhabitants on that distant planet, would not even be aware of our existence. The poet truly asks, " Why should the spirit of mortal be proud ? "

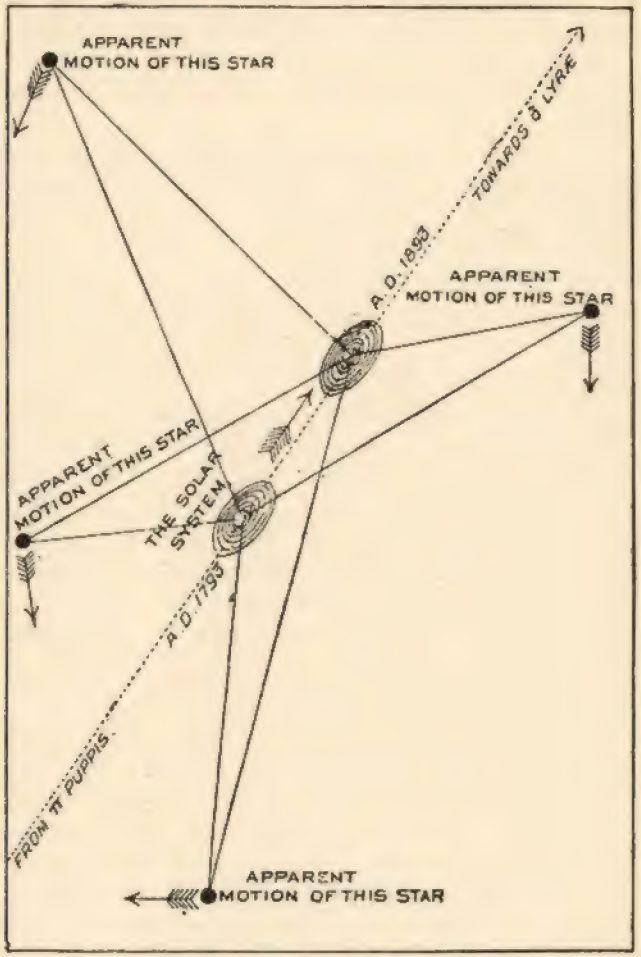
Alpha Centauri cannot be seen in northern latitudes, but only in southern skies, so if any of my young readers are planning to communicate by means of wireless with inhabitants (if any exist !) of that distant world, they should journey to Africa, Australasia, or South America to conduct their experiments. Should they succeed in transmitting with the speed of light, the messages would take over four years to arrive.

Is it not a wonderful thought that in every second of time the Sun advances twelve miles, so that by the end of each day it is more than a million miles nearer the bourne for which it is bound ? Our illustration shows how the Solar System has moved in the space of one hundred years. The dotted line points in the direction of the star Delta in the constellation of Lyra. At each side of this dotted line two stars are shown with arrows pointing in opposite directions, indicating that the stars are drifting one way and the Sun another.

You must not imagine that these stars are actually seen in the sky decorated with arrows in this way. Should you be so simple you would be like the Prince of Orange already referred to, who visited the great observatory at Slough and asked Herschel absurd questions.

It was Sir William Herschel who first made the suggestion that if the stars are drifting (for before that time they were supposed to be fixed), then as the Sun is a star it must be moving as well. He made a guess, and a very good guess it proved to be, that the Sun is drifting toward a certain part of the sky, in the direction of the star Lambda in the constellation Hercules. Later and

more up-to-date calculations have shown that the drift is toward the star Delta in the constellation of Lyra, but



THE VOYAGE OF THE SOLAR SYSTEM
From "In the High Heavens," by Sir Robert Ball

even so, if you will look at a star-map, you will find these stars are comparatively near neighbours in the sky.

All these problems seem simple after they are solved, but this one required an immense amount of work from Herschel, who founded his observations in 1783 on the changing position of seven stars. He noticed that as the Sun made its way across the ocean of space, the distances between certain stars it was approaching seemed to open out, while others from which it was receding drew nearer together, and he had to take into account the drift of the Sun itself. It reminds me of those nice little calculations of speed in algebra as to Jones who is rowing upstream while Smith and Robinson are rowing downstream, though the following is a more apt illustration.

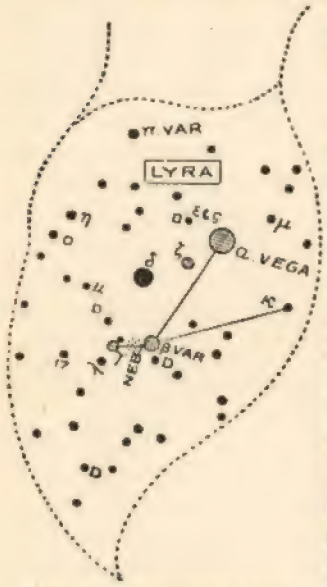
If you have made a journey in a steamship and have reached port at night, unless the motion of the ship was too disturbing you must have noticed, while still at some distance from the harbour, two bright lights seemingly close together. If you are of a turn of mind similar to that of the 'stute fish in the *Just So Stories* who was troubled with an "insatiable curiosity," you will have inquired what the lights are, and it will have surprised you to hear that they are lights on each side of the harbour, and that the ship is to pass between them.

You may have doubted the truth of the information, for the lights seem too close to each other for even a fishing-boat to pass between them. However, if you continued to watch you would have noticed that as the ship approached them the lights appeared to open out and that by the time the mouth of the harbour was reached there was ample room for the biggest ship to pass between.

If on the return voyage you left the harbour at night no doubt you looked out for the lights again and observed that as the ship steamed away the lights seemed to draw together again, and that at a certain distance they were very close, and at last it was difficult to distinguish their light from those on boats moving to and fro in the harbour.

This is exactly what Herschel noted with regard to

the stars, as he charted their position in the sky. He would call down to Caroline, who was patiently waiting as usual to record her brother's observations. From the positions thus recorded it was found that the Sun (like the ship) was drifting forward, in the direction of Lambda, the distances between the stars opening out like the lights at the harbour mouth.



THE CONSTELLATION LYRA
From "In the High Heavens," by Sir Robert Ball

In the chart of the constellation Lyra you will see to the right of the star Delta the star Vega, and perhaps you may like to know how to find this in the heavens. It is best to look for it during the month of August, when it is overhead at 9 P.M. (not summer time, which would make it 10 P.M.). Lyra is well placed for observation throughout September also, when it can be seen nearly overhead early in the evening. It is to the right of the constellation of Cygnus, the Swan, which looks like a large cross outspread against the hazy light of the stars in the Milky Way. Vega is easy to find, for it is of the first magnitude [1] and is so bright that it stands out clearly in a part of the sky where it has no rival.

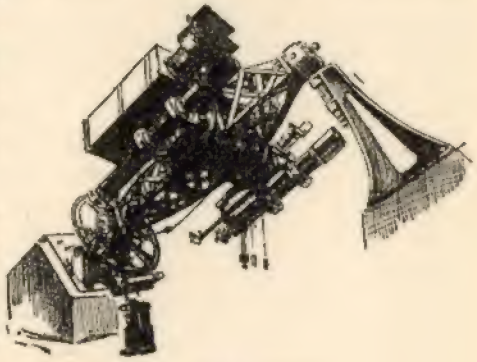
In 1897 I was present at an address given by Professor Newcomb, when he made the following interesting reference to this star:

> I have seldom felt a more delicious sense of repose than when crossing the ocean during the summer months I sought a place where I could be alone on the deck, look up at the constellations, with Lyra near the zenith, and while listening to the clank of the

[1] Magnitude is a measure of brightness, not size.

> engine, try to calculate the hundreds of millions of years which would be required for our ship to reach the star Alpha Lyrae [Vega], if she could continue her course in that direction without ever stopping.

But that is exactly what we are doing every year, every hour, every minute of time. While five minutes have come and gone, we have advanced 3,600 miles on this wondrous voyage of the Solar System. If our path as we circle round the Sun could be traced in silver it would appear as a spiral in outline, and the Sun's path, if traced in gold, would appear as a seemingly straight line. But in course of time this may eventually curve under the influence of some star which may be its companion in space, for lonely stars are rare.



A STAR CAMERA

The stars are now under observation from an eye which is able to detect details which would escape the keenest astronomer. This is a camera which by means of a clockwork adjustment follows the stars in their apparent motion across the sky. (Of course it is the movement of the Earth which needs to be counteracted.) But for the ability of the camera to keep its film accurately pointed at the stars under observation throughout the whole time of exposure, the stars photographed, instead of appearing like points of light, would be shown as long drawn-out trails, similar to the effect in the two views of comets facing p. 168.

Thus, we see that the voyage across the Ocean of Space of the Solar System far surpasses in wonder anything we have read about in *The Arabian Nights* with

its magic horses and enchanted carpets. These transported people hither and thither at a moment's notice, but here are we on our planet Earth, progressing daily *a million miles* without jolt or jar, ever guided by our bright Day Star the Sun, whose unseen influence holds us to our course.

And so the Sun drifts onward, ever gathering new material such as comets and meteor-swarms which it may meet on the way, but whither it is taking us and how the journey will end, who can tell ? Yet if, as astronomers say, the Sun is moving in a mighty curve, the voyage of the Solar System may be after the plan of what is termed Great Circle Sailing, about which you will learn some day if you should become captain of a ship of your own.

CHAPTER XVI

THE GREAT BEAR IN FACT AND FANCY

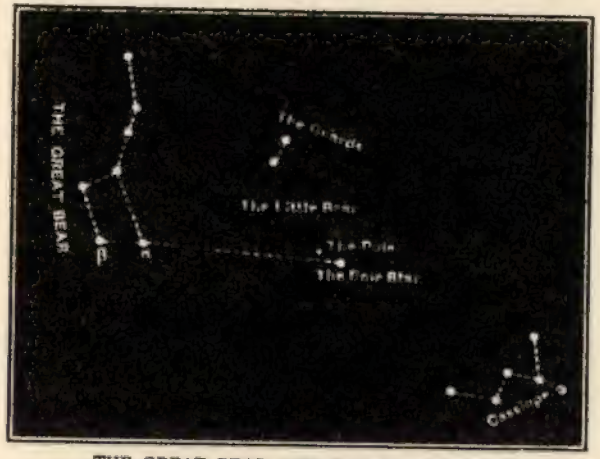
EVERY Boy Scout or Girl Guide knows this familiar group of seven stars—though they are only a part of the entire outline of a bear, and the whole is much less familiar. They serve the extremely useful purpose of showing the position of the Pole Star, or Polaris. A former Astronomer Royal during the course of a lecture said :

> I presume you know which is the Polar Star, I presume also that you know which is the Great Bear. Now, these are objects of such importance that nobody ought to think of entering an astronomical lecture-room who is not acquainted with them.

Go out some fine evening when the stars are shining and see if you can locate the Pole Star. You may see it just above some object such as the spire of a church or a tree, and next time you look for it, with this object for a guide, you will notice that the star is in the same place, or very nearly so, since it moves in a small circle. If, also, you examine the stars of Ursa Major, or the Great Bear, you will observe that they move in a circle much larger than that of the Pole Star, but the whole of the circle is always within view on a clear night. The stars move round the whole circle and are ever above the horizon. Thus, as Scouts know, the constellation forms a clock in the sky, and enables one to make a fairly good guess with regard to the time.

Next let us look in the constellation Auriga, the Charioteer, for the bright star Capella. You will find that this also describes a circle of which the Pole Star appears to be the centre, but if you note its position

carefully you will find that it travels in a larger circle than that traced by the stars of the Great Bear. It is very near the horizon when lowest in the north, and almost overhead when highest in the south. It is my favourite star, for when it peeps above the north-eastern



THE GREAT BEAR AND THE LITTLE BEAR

horizon and brings the mournful message that winter is near, it twinkles so merrily. When the trees are bare and the nights have become chilly, then Capella shines out boldly overhead. On old maps which illustrate the legends of the stars the Charioteer is shown seated on a chair in the Milky Way, carrying a goat on his left arm. Capella glows as the heart of the goat. To the Greeks Auriga represented Erechtheus who is said to have invented the four-horse chariot, for which he was rewarded by Jupiter with a place among the stars :

> The charioteer who gained by skill of old
> His name in heaven, as first his steeds he drove
> With flying wheels, seen and installed by Jove.

Vega, the third bright star of which you have just been reading, also moves in a circle round the Pole Star,

but a wider one than Capella's and therefore beyond that star. It passes very near the horizon, in the south of England it just descends below to the north, but during the summer months it is very noticeable overhead. In the month of July, for instance, Vega is almost exactly midway between the points north and south. Between Vega and Capella, which is now due north, is the Pole Star, so that the three are in almost a line, though curved. Suppose that the church spire points to Polaris, then you will find, if you watch it each night during the course of a year, that the seven stars of the Great Bear, Capella, and Vega describe circles round it, and that there are other stars which rise in the east, pass the south, and go down in the west, until they are lost below the horizon and are not seen again until the season for their return.

AURIGA

Thus Orion is visible in the winter months, but it is no use looking for it in summer for it is then hidden from view in the glare of sunlight. During the day the stars are overhead as during the night, but we cannot see them until the Sun has set, and in the slowly darkening sky they make their appearance, as Longfellow so beautifully expresses it :

> Silently, one by one, in the infinite meadows of Heaven
> Blossom'd the lovely stars, the forget-me-nots of the angels.

Nor do the constellations actually describe circles in the sky ; it is our planet which is slowly turning round, so that the stars seem to rise and set, or to

circle partly round the Pole Star, during the course of a night.

This may sound a little difficult, but there is nothing like watching and seeing for yourself; you will thus learn more than any book, however clearly written, can teach you. I once heard a great astronomer remark: "If you want to learn about the stars as they seem to circle round the Pole Star, watch them for a whole night, if possible, from twilight until dawn." This is easier said than done, but it can be done with an effort.

Should you, one of these days, be inclined to keep such a vigil, select a suitable place where there is a clear view of the sky all round. A rug spread on the ground, which may be covered with dew, will add to your comfort, and a cushion on which to rest the head is not amiss. A good field-glass is handy, because it shows a great deal more than can be seen with the unaided eye. An electric torch is useful for reference to star charts, but it is far better to have a guide who knows the stars and can tell all about the wonders overhead. Such a guide on a ramble in Starland is to blame if he fails to keep his party awake.

From my own experience, it is well to rest quietly during the day preceding. On the night of the vigil, an hour's rest and a cup of coffee kept hot in a thermos flask is a good break in the programme about midnight. By one o'clock all should be wide awake again, and it will be interesting to note the change in the position of the stars, including groups of stars which were visible in the eastern horizon from early in the evening, and others which gradually came into view before dawn. If you have watched from evening till dawn you will have seen constellations which were rising early in the evening in the east setting in the west about dawn, and an entirely new group of stars coming into view.

My first attempt to watch the stars all night was made on board the S.S. *Makura*, steaming south from Honolulu.

I had noticed on previous evenings that new groups of stars were coming into view. My old friends Polaris, Capella, and Vega were no longer visible, and I felt homesick for the starry friends I had left behind me.

One morning, about 2 A.M., when we were passing through the Tropics and the heat made sleep impossible I dressed and went on deck, which was lonely and deserted. I was enjoying myself gazing at the stars and trying to make their acquaintance, when the officer on the bridge, noticing the lonely watcher near the rail, sent a sailor to inquire if I was "contemplating suicide." This abruptly ended my first all-night vigil.

An evening or so later, when I began my watch shortly after dinner, the same sailor was sent by the captain to tell me that he wished to introduce me to a friend on the bridge. When I arrived, I found only the captain and one of the officers. "Who is the friend?" I asked, and in reply the captain pointed to the stars of the Southern Cross, which were nearly overhead and attended, to the left, by Alpha Centauri (the nearest star) and Beta Centauri, and, to the right, by the two brightest stars in the heavens, Canopus and Sirius. He pointed to the outline of Argo, the ship of which Canopus forms part, on one side of the Southern Cross, and the Scorpion, which gleamed between the point overhead and the eastern horizon, instead of crawling round the southern horizon, as it seems to do when seen in the northern hemisphere. I shall always feel that I owe Captain Gibbs a deep debt of gratitude for thus introducing me to the Southern Cross at a time when it is seen at its best. When I mentioned my desire to watch the stars all night,

THE SOUTHERN CROSS

it was politely hinted that the decks had to be cleaned, and this was the only time they could be 'cleared for action.'

My opportunity came in the year 1913, when I was a guest of Mrs Evershed, the wife of the Director of the Kodaikanal Observatory in Southern India. The Observatory is six thousand feet above the level of the plain below, with a clear view of the whole sky. Moreover, it is only ten degrees north of the equator. The conditions were ideal, as it was possible to see not only the southern constellations but many northern ones as well.

Mrs Evershed very kindly offered to share my vigil and made every possible arrangement for our comfort. The observations were to be made from outside the building containing the spectroheliograph used for photographing the Sun. Two camp-beds were provided in case we might need a rest during the night, and a midnight meal was in readiness.

An important addition to our party was the dog Max, for panthers or bears might prowl around during the night. As a matter of fact, Max proved merely an ornament, for the first thing he did was to seek the most comfortable-looking camp-bed, which happened to be mine, as Mrs Evershed had piled on it most of the rugs and cushions, and there he curled up and went to sleep. When at midnight, very tired, I wanted to do likewise it was difficult to make him budge, so I shared the bed with him. Dear old Max, he has long since joined the silent majority of bow-wows.

Perhaps what impressed me most was not the view of the Southern Cross, but when Mrs Evershed said, " Turn round, and see what is behind you," I did so rather timidly, wondering whether it might not be a panther. It was a bear—not a real bear, but the group of stars known by that name. Even so it was only that part of the constellation, the group of seven stars, which is known as the Dipper, or the Plough. Four of the stars

THE SOUTHERN CROSS AND COAL-SACK 208

Photographed at the Union Observatory, Johannesburg

[See p. 221]

SOME OLD CONSTELLATION FIGURES 203

From Burritt's *Geography of the Heavens*

[*See p. 204*]

form the plough, and three the horses. Two of the stars as you already know, are known as the Pointers because they point to the Pole Star, which is distant about five times the space which separates them. We saw the Pole Star just above two trees dimly in the darkness. They were eucalyptus, tall and slender. It remained there all night, while the Bear pulled himself up and the other constellations marched on in their courses.

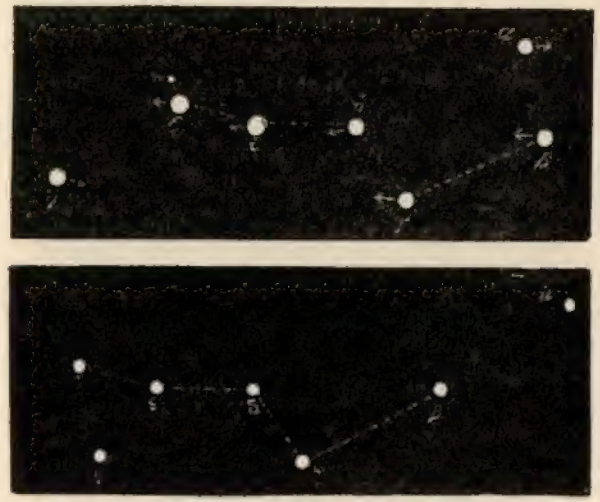
It was the first time I had seen these stars since my farewell to them after leaving Honolulu, a year or so earlier, and I felt as one does in meeting old friends. By half-past eleven the Southern Cross was well above the horizon, and by midnight Orion was overhead, but inverted, so that he appeared to be standing on his head. Somehow, this group of stars did not look nearly as impressive as it does when seen in northern skies. There we see it in full glory due south :

> Begirt with many a blazing star,
> Stands the great giant Algebar,
> Orion, hunter of the beast :
> His sword hangs gleaming by his side,
> And on his arm the lion's hide
> Scatters across the midnight air
> The golden radiance of his hair.

The Milky Way seemed to be thickly powdered with millions of small stars. Near the dawn we watched these as they gradually faded, until sunrise hid them from view. It was a wonderful experience, and one which I hope to repeat some day, but it is not often one is able to watch the stars all night, nor to see at one and the same time constellations visible in northern and southern skies.

It is interesting to know that the seven stars of the Plough form a family party which in the course of time will separate, for the spectroscope—the Sherlock Holmes of the sky—has shown that two are drifting in one direction, and five in another. A chart which my father

made in 1868 shows an arrow attached to each star. It will be seen that five of the arrows are pointing in one direction and two in the opposite. The arrow-tips indicate where each star will be 36,000 years hence. The second chart shows the group as it will appear 100,000



THE GREAT BEAR (*a*) AS IT IS, AND (*b*) AS IT WILL BE 100,000 YEARS HENCE

From "Easy Star Lessons," by R. A. Proctor

years hence. If there are schools at that remote period, and Boy Scouts and Girl Guides, they will have to use another set of star-maps, for the appearance of the constellations will probably have altered greatly by that time.

This is due to what my father termed star-drift, for just as the Sun is drifting ever onward at the rate of twelve miles a second, so are the stars travelling, though at varying rates of speed, some going in one direction, as the stars in the Plough, and some in another. Moreover, there are two great streams of stars which intermingle like people in a crowded thoroughfare, but there is no

jostling that we are aware of, except rarely, maybe, when a sudden flare-up indicates a collision, for the distances separating the stars from each other are so vast.

Each star, like the Sun, is a great mass of glowing gas, surrounded by an atmosphere composed of a mixture of iron steam, calcium steam, and many other such fiery vapours, besides hydrogen. All these are so intensely hot that they shine with their own fierce glow. Imagine an atmosphere where the clouds are formed of metallic drops, and the rains which fall are sheets of molten metal.

The Great Bear is the most widely known of all the constellations. Not only the ancient inhabitants of the valley of the Euphrates, but the old Greeks also, described its outline as resembling that of a bear.

> He who would scan the figured skies
> Their brightest gems to tell,
> Must first direct his mind's eye north
> And learn the Bear's stars well.

The best-known legend which tells why this constellation received its name dates back to the days when Jupiter was said to live on the top of Mount Olympus with his beautiful wife Juno. She was a very jealous goddess, and when she heard that Callisto, daughter of the King Lycaon, had boasted of her beauty, Juno asked Jupiter to avenge the slight on her own good looks. Fearing that Juno might harm the princess, he changed her into a bear. But this led to further trouble, for while Callisto's son Arcas was hunting one day, he saw the bear and would have killed it had not Jupiter changed him quickly into a little bear. To avoid disaster the god then fixed mother and son near each other in the sky. The unusual length of the great bear's tail is explained by the legend that Jupiter stretched it when he swung her up into the sky.

The Arabic names for the seven stars are Dubhe, Merak, Megrez, Phecda—the four representing a waggon —and Alioth, Mizar, and Benetnasch, these being three

horses which draw the waggon round and round the Pole Star. Near Mizar is a small star named Alcor, which means 'the Rider.' It was considered a good test for eyesight to be able to see this with the unaided eye, but it must have brightened up recently, as it is now quite easy to do so. The Algonquin Indians called this constellation 'the Bear and the Hunters.' To them four stars were the bear, and the three stars three hunters in pursuit of the bear. According to the legend the first hunter carries his bow and arrows, with which to kill the bear, the second hunter carries sticks, with which he will make a fire when the bear is caught, and the third hunter carries a kettle, in which the bear will be cooked. Only once a year does the first hunter succeed in piercing the bear with an arrow, and the blood from the wound is supposed to tinge the ruddy autumn leaves with their bright red hues. This is the time when Glooksap, the Indian god, smokes the pipe of peace which is supposed to produce the misty haze which forms a background for the gorgeous display in the Indian forests.

In America this group of seven stars is usually referred to as the Great Dipper, from the resemblance of its outline to an oblong-shaped cup with a curved handle. The group known in England as the Little Bear in America is called the Little Dipper. The English have also termed the Plough Charles' Wain (waggon). The four stars are the waggon, and the three stars are the horses.

The following quaint extract from a book written in 1590[1] shows the state of astronomical science at that time :

> *Scholar.* I marvel why, seeing she [Ursa Major] hath the form of a beare, her tayle should be so long.
>
> *Master.* I imagine that Jupiter fearing to come nigh unto her teeth, layde hold of her tayle, and thereby drew her up into heaven, so that shee of herself being very weightye, and the distance from the earth to the heavens very great, there was great likelihood that her tayle must stretch. Other reason know I none.

[1] Memoir of Augustus De Morgan.

If you look at Alcor with a glass you may be able to see Sidus Ludovicianum, a tiny star with a long name, which Herschel discovered more than a hundred and fifty years ago and named after a German prince. You must look very sharply if you expect to see it, and your opera-glass must be a large and strong one. A field-glass, however, cannot fail to show it plainly. The spectroscope, that keen detective of the stars, revealed that Mizar, Alcor the rider, and the tiny star discovered by Herschel are each accompanied by an attendant star. There are six stars in this little group, though the unaided eye can see but two, and the ordinary telescope three. Thus, by means of instruments which highly magnify, we see that Alcor is a long way from Mizar and that Mizar itself is two suns close together. This fact can be seen with a small telescope, and Mizar is the best example in the heavens for starting observations of double stars, of which there are so many.

The discovery of double stars by Sir William Herschel proved that the great law of gravitation extends throughout the universe. As Sir Robert Ball so excellently describes it :

> From the binary [double] stars came a whisper across the vast abyss of space. That whisper told us that the law of gravitation was not peculiar to the Solar System. It told us the law extended to the distant shores of the abyss in which our island is situated. It gives us grounds for believing that the law of gravitation is obeyed throughout the length, breadth, and depth of the entire visible universe.

CHAPTER XVII

THE DRAGON AND THE SCORPION

This dragon had two furious wings,
  Each one upon each shoulder ;
With a sting in his tayl, as long as a flayl,
  Which made him bolder and bolder.
He had long claws, and in his jaws
  Four and forty teeth of iron ;
With a hide as tough as any buff,
  Which did him round environ.

PERCY, *Reliques*

WHILE this is a very good description of the outline of the constellation of Draco, the Dragon, seen in old-time charts, yet the vast Dragon twines harmless enough between the stars of the Great and the Little Bears. The two bright stars marking the eyes of the Dragon are almost exactly overhead at nine o'clock (summer time) on August 22nd, the tip of its tail being midway between the Pointers and the Pole Star, which marks the tip of the tail of the Little Bear. The outline of the Dragon can be easily traced, and it is surprising how the eye glances naturally from star to star, so that before you are aware of the fact you have reached the tip of its tail.

According to the Greek legend this was the Dragon which kept watch in the Garden of the Hesperides over the golden apples which Juno gave to Jupiter. She rewarded the Dragon for guarding them by placing it among the stars after it had been slain by Hercules. In star-maps Hercules is shown with his right foot " planted on the crest of the coiled Dragon."

Others say that this was the snake snatched by Minerva

from the giants, and hurled to the sky before it had time to uncoil its folds. In the story of Phaeton, who tried to ride the chariot of the Sun, it is said that the Dragon, scorched by the heat as the chariot came closer than usual, grew warm and felt its rage revive.

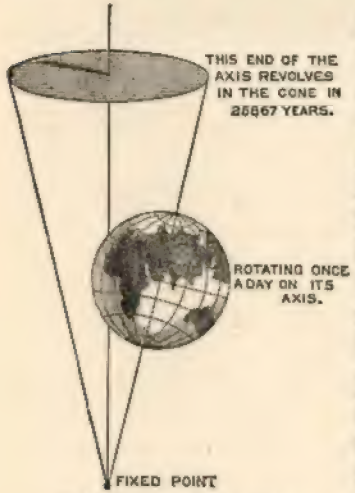
To the fanciful Oriental mind the stars of the Dragon winding round the north pole of the heavens seemed a

THE DRAGON

great winged monster encircling the dome of the sky. Moreover, it was noticed that one of the group, Thuban, seemed to remain still in the sky. Because the whole constellation of the Dragon swings round this star as on a pivot, it was known in China as ' the Right-hand Pivot.' To find Thuban, trace the curve of the stars from Polaris to Mizar. Thuban is the star in the Dragon which is almost on a line with Mizar.

Thuban is connected with the great pyramid of Cheops in Egypt, for there is a long sloping passage within that leads straight toward the north from a room cut deep in the rock beneath the centre of the pyramid. It is believed that the upward slope of this passage (which is four feet high, three feet wide, and three hundred and eighty feet long) was directed toward Thuban, and used by the astronomer-priests of those days as a telescope tube for viewing what was then the Pole Star.

This was about three thousand years ago, and on the walls of the passage are strange wizard signs such as we read about in *Guy Mannering*, where Sir Walter Scott describes the way astrologers pretended that they were able to see signs and meanings in the stars which enabled them to foretell the fate of mortals. These soothsayers must have noted that Thuban was not *exactly* at the Pole, but revolved every twenty-four hours in a tiny circle about it, and consequently crossed the meridian twice a day, once above and once beneath the true Pole. What use they made of this simple observation in foretelling events is of no importance; its interest to-day lies in the fact that it taught them that the Earth rotated. They must have discovered, also, that an imaginary line extended upward from the swiftly turning Earth would reach near to Thuban, the Pole Star of 3,000 years ago.



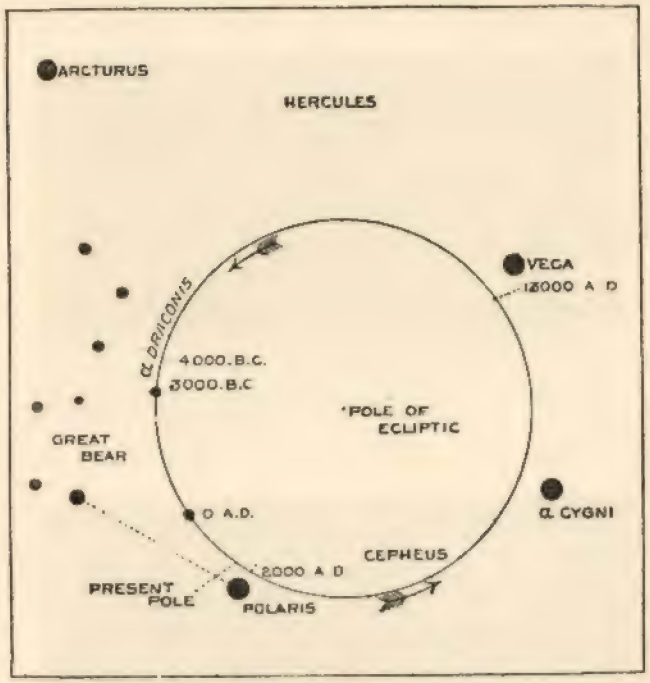
ROTATION OF THE POLE

From "In the High Heavens," by Sir Robert Ball

A simple experiment may help you to understand this. Get out a peg-top and set it spinning. Watch it as it swiftly turns, remaining almost upright at first and then revolving in larger and larger curves, until finally it falls over. The Earth is like a gigantic top spinning upon an axis (an imaginary line running from the Pole Star through the Earth from pole to pole and ending at a fixed point, as shown in our illustration) and this axis itself is slowly performing a conical movement round what I may perhaps term a polar circle in the heavens so vast that it takes more than 25,000 years to complete the circuit. Our celestial top imitates the peg-top, but it does not fall over. No, the Sun

and Moon see to that, for by the force of gravity they help to keep it upright.

As the axis moves round this vast polar circle above referred to the Pole Star alters. Thuban and not Polaris



THE MOVEMENT OF THE CELESTIAL POLE

From "In the High Heavens," by Sir Robert Ball

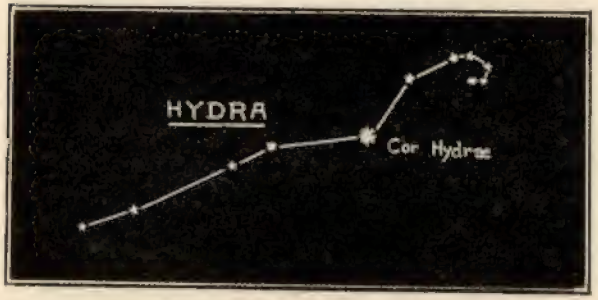
was the Pole Star of 3,000 years ago; the Pole Star of 13000 A.D. will be Vega, and so on, until in 25,000 years or so the turn of Polaris will come again.

It seems very natural that snakes and serpents being plentiful in Arabia and Egypt, the people of those countries should trace their outlines among the stars.

There is Hydra, situated south of the Zodiac below Cancer, Leo, and Virgo; Hydrus, situated near the

south pole; Draco, circling round the north pole, and Serpens,

> The starry serpent, that on high
> Tracks the clear ether, and divides the sky
> And southward winding from the Northern Wain,
> Shoots to remoter spheres its glittering train.



THE CONSTELLATION HYDRA

The Serpent is represented as grasped in both hands by Ophiuchus, the serpent-bearer. According to legend

THE CONSTELLATION OPHIUCHUS

Ophiuchus is the physician Aesculapius, son of Apollo, who was instructed in the art of healing by Chiron, the Centaur. The serpent in his hands reminds one of his skill in healing the bite of this reptile.

Far more imposing is the outline of the famous scorpion

which is said to have sprung out of the earth at the command of Juno and stung Orion the mighty hunter, of which wound he died. As a reward for obeying this command Juno gave the scorpion a place among the stars. The constellations of Orion and the Scorpion are never visible in the sky at the same time, for when one is

THE SCORPION

rising in the east the other will be setting in the west; therefore it is useless searching for the stars of Orion in the eastern sky until the stars of the Scorpion have disappeared below the western horizon. During the month of October neither constellation can be seen, but in November, evidently knowing that the coast is clear, Orion appears above the eastern horizon and can be seen every night until the end of April. During the month of May the last star, Betelgeux, which marks Orion's left shoulder, is all that remains "glimmering low down in the west."

During the month of June the Scorpion is seen at its best in northern skies, but this does not compare with its appearance as seen in Australasian skies, where its whole length becomes visible overhead, from the bright stars marking its head to the tip of its tail. Antares, the brilliant red star which marks its heart, was called 'the

Fire Star' by the Chinese, and on the Euphrates it was 'the Vermilion Star,' and 'the Day-Heaven-Bird.'

Antares has a small emerald-green companion, the contrast in colours, fiery red and vivid green, being quite distinct. An observer describes the little green star as coming from behind the Moon ahead of its ruddy companion. Seen with an opera-glass the small green star seems to be almost touching Antares. The glass will also reveal a number of stars scattered around Antares, and to the right of that star can be seen a cluster which looks like a hazy speck. A field-glass will show that there are stars closely packed together in the cluster, and if you are fortunate enough to get a glimpse of it through a telescope you will see a bright array of stars.

These are among the wonders revealed when we look at the stars with an opera-glass or a field-glass, and the regions around and within the constellation of the Scorpion are rich in celestial treasure-trove. As Mr Serviss says in *Astronomy with an Opera-glass*:

> These glimmering specks are the lights in the windows of the universe which carry to us, across inconceivable tracts of space, the assurance that we and our little system are not alone in the heavens; that all around us, Nature is busy, as she is here, and the laws of light, heat, gravitation (and why not of life?) are in full activity.

It is surprising how varied are the colours of the stars. If we look at them with an opera-glass we generally find, as in the case of Antares, a small star nestling close to the brighter one, and its colour will not be the same. If the larger star is orange the smaller one will probably be blue; or if the larger one is red the smaller may be green. One of the prettiest sights I have seen in the way of coloured stars was in Australia, upon my first visit to Sydney Observatory.

The telescope was turned in the direction of the little star Kappa Crucis, which hovers on the edge of what looks like a black hole in the sky and is usually termed by

mariners the Coal-sack.[1] First, a look was taken at this star. Instead of one not particularly bright star, as it appeared when seen with the unaided eye, observed with a telescope this proved to be a cluster of over one hundred stars, bright, glittering points of light, red, green, blue, purple, orange, and every tint one can imagine. These were all closely packed together so that the cluster has been compared to a superb piece of jewellery, or "a casket of gems." A glance at the Coal-sack showed that it is fairly well filled with stars; a photograph of it shows at least six thousand!

[1] See illustration facing p. 208.

CHAPTER XVIII

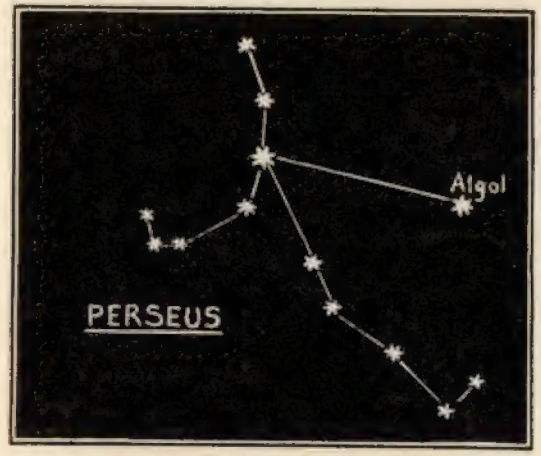
THE STORY OF ALGOL, THE DEMON STAR

IN the days of old, when people believed that the stars had a good or evil influence over the fate of mortals, they looked with awe upon a star in the constellation Perseus which seemed to wink at them from out the depths of space. The Arabians called it Algol, the Demon Star, or the Blinking Demon (their word *Al-ghul* means monster or demon). They had no idea that what they saw was caused by a dark globe which circles round Algol at regular intervals, cutting off part of its light, as happens when a person passes to and fro in front of a lamp on a table, or when the wick of a lamp is raised and lowered at regular intervals. It was not until the spectroscope was directed upon it in 1889 by Professor Vogel that the cause of the 'winking' was explained and the suspicions of the ignorant were set at rest.

Vogel discovered when the light of the star was spread out before him, after passing through the spectroscope, that it had a double record, instead of the single one he had expected. This proved very clearly that Algol had a companion, and it was found that the two stars revolved round each other with the regularity of a dance.

We can imagine Vogel taking off his spectacles, polishing them, and again examining the records to make sure that he was not mistaken. He kept a careful watch on the dancers so that he might learn all about their steps, which are very rapid in one direction, but slow in another. Algol, he found, takes seventeen hours to step backward, though he does so at the rate of twenty-seven

miles a second, which, seeing that he is over a million miles in diameter, is very nimble. As he steps back his companion steps forward at the same rate of speed, and the two revolve round each other in a path nearly edgewise to the Earth. When the companion is exactly between us and Algol, the latter's light is reduced to



THE CONSTELLATION PERSEUS

three-fifths of its usual brightness, but this only lasts for twenty minutes, and within four and a half hours the darker companion has passed from in front of Algol, which then shines out as brilliantly as ever. The whole cycle of changes occupies 2 days 20 hours 48 minutes 52 seconds, and explains why Algol seemed to the Arabians to be like a bright eye opening and shutting.

Several years ago Sir Robert Ball made the following humorous reference to Algol:

> The star behaved in a most ill-bred manner. He would advance, wink, and then retire. For years his motion and behaviour puzzled astronomers, until at last the mystery was solved by Professor Vogel, who showed that Algol had associated with him a dark star, which was invisible, and that the latter sometimes obscured the former. Algol and his invisible playmate revolved

round each other, and this accounted for the fact that Algol seemed to wink.

The companion, which only seems dark in comparison with Algol, is quite as bright as our Sun and about the same size. To get an idea of the comparative size and distance from each other of the two, place a shilling, to represent Algol, and a sixpence, its companion star, two inches apart on a table. The circle in which Algol revolves could hardly seem larger to us than a threepenny bit would appear if it could be seen from a position five hundred miles away. That is why detective spectroscope was called in ; it has the uncanny power of revealing facts which no other instrument can discover.

The *Nautical Almanac* tells us exactly when Algol's light waxes and wanes, and should this occur during the month of August or September may I suggest that you follow my example of some years ago and watch these changes for yourself? No telescope is required, but an ordinary opera-glass or field-glass will be helpful. If you have neither, the changes in brightness are plainly visible to the unaided eye throughout.

On September 14th, 1910, I found from an entry in my notebook that Algol would gradually grow dim during the course of the night and regain its usual brilliancy about 1 A.M. or thereabouts. This was a favourable opportunity, so I made up my mind to observe the variation, that I might be able to give the benefit of my experience to others.

Knowing that Algol would be faintest at about a quarter to ten I began my observations at a quarter to eight from the flat roof of the Yerkes Observatory. There was ample room, since the entire length of the building is three hundred and twenty-six feet, and I was alone in my vigil.

I had been careful to observe Algol every night for some evenings previously, so as to know how bright it usually is when at its best in comparison with near-by

stars. A few degrees south of Algol and almost in a direct line with it and Alpha in Perseus is a small third-magnitude star known as Rho. As this is fainter than Algol, my idea was to compare the two stars, as Algol faded, with Alpha in Perseus, which retains its brightness unaltered.

At a quarter to eight I noticed a difference in the appearance of Algol as compared with Alpha, and during the course of the next hour it became so dim that its light only equalled the lesser light of Rho. By 9.45 it was not even as bright as that star. For about eight or ten minutes, possibly a little longer, as a cloud drifted over it about 9.55, Algol remained dim. Then it slowly recovered its former brilliancy, and by one o'clock was itself again.

All these observations were made with the unaided eye, the star being plainly visible throughout, but it was interesting once in a while to look through an opera-glass. At the end of my vigil it was surprising to note the change which had taken place in the appearance of the sky. The constellations which had been visible early in the evening had gradually drifted westward, new groups were approaching from the east, and Capella, which was just rising above the tree-tops smiling a welcome at me when I began my observations early in the evening, was now beaming down on me from directly overhead.

Enchanted with the sight I watched the Pleiades glittering south of Algol, "like a swarm of fireflies tangled in a silver braid." The fiery gleam of Aldebaran in the constellation of Taurus had announced the approach of Orion, which now filled with splendour the south-eastern sky, while Sirius came gradually into view above the low-lying mists, flashing like a diamond in the sky. On the opposite shore of Lake Geneva, Wisconsin, which the Yerkes Observatory overlooks, lights twinkled here and there, but these earth-stars—as I once heard a child call them—as well as the stars

overhead, faded at the approach of dawn, and the celestial drama was ended.

According to a Greek legend the constellation of Perseus was named after the hero who rescued the fair Andromeda from a terrible fate. He was so loved by the gods that they placed him among the stars with Andromeda and her mother, Cassiopeia. The latter appears among the stars within a group which looks like a W but is supposed to outline a chair on which Cassiopeia reclines.

PERSEUS SLAYING THE SEA-MONSTER

As you may remember, the Great Bear was said to be Callisto, who boasted of her beauty and was placed among the stars as a punishment for her vanity. The same fate seems to have overtaken Cassiopeia, who, with her husband Cepheus, King of Ethiopia, occupies the position on the opposite side of the Pole Star.

Cassiopeia, it seems, boasted that her daughter, Andromeda, was more beautiful than the sea-nymphs and mermaids, who complained to their king, Neptune. To avenge this slight, Neptune ordered that Andromeda should be fastened to a rock on the seashore and that a monster should be sent to devour her.

Kingsley gives a most thrilling account of what followed :

> On came the great sea-monster, coasting along like a huge black galley, lazily breasting the ripple, and stopping at times by creek or headland to watch for the laughter of girls at their

NEBULA IN ANDROMEDA

Photographed by Professor G. W. Ritchey with the 60-inch reflector at Mount Wilson Observatory

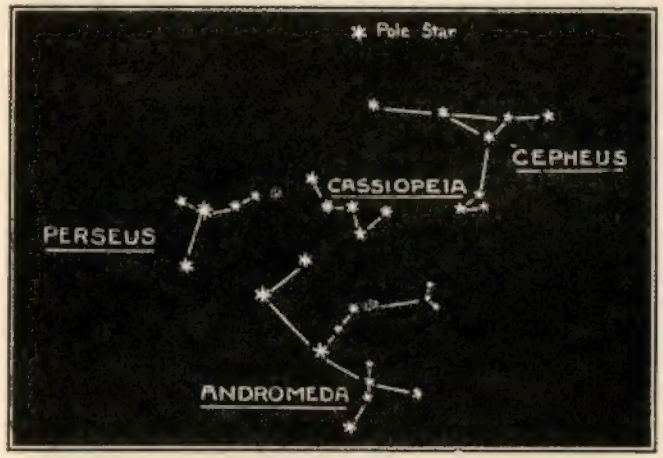
THE SEVEN SISTERS 227

Photographed by Dr Isaac Roberts at Crowborough, Sussex

[See p. 235]

bleaching, or cattle pawing on the sand-hills, or boys bathing on the beach. His great sides were fringed with clustering shells and sea-weeds, and the water gurgled in and out of his wide jaws as he rolled along, dripping and glistening in the beams of the morning sun. At last he saw Andromeda, and shot forward to take his prey, while the waves foamed white behind him, and before him the fish fled leaping.

Just at this moment, Perseus, who had been sent by his enemies (hoping that he would never return) to bring



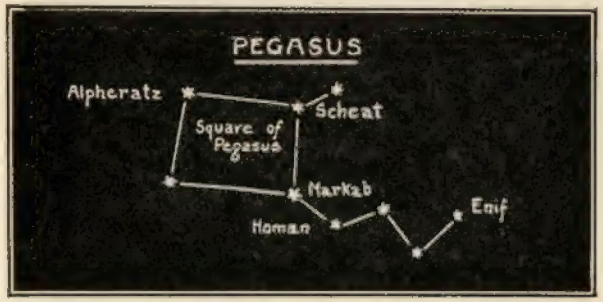
FAIRY-TALES IN THE HEAVENS

back the head of Medusa, whose beautiful hair had been changed into hissing serpents by the goddess Minerva, whom she had offended, and whose face turned to stone all who looked upon it, was returning successful. He had borrowed Mercury's winged sandals and so was able to fly through the air swiftly. Seeing the terrible plight of Andromeda, he swooped down upon the monster, shouting a warning to the maiden to turn away her eyes lest she might be turned to stone. When he told her all was well she looked where the sea-monster once had been but "instead of the monster she saw a long, black rock, with the sea rippling quietly round it."

Perseus had turned the monster to stone by holding the head of Medusa before its eyes, and we see it now among the stars in the constellation of Cetus, the Whale. There is the whole story shining from the heavens in these groups, beginning with Cepheus and Cassiopeia, Andromeda and her rescuer Perseus, the star Algol—representing Medusa's evil eye—and Cetus, the monster, at a little distance. During the month of January all these constellations are to be seen, Cepheus being to the left of the Pole Star, Cassiopeia to the south of Cepheus, and Perseus and Andromeda to the south of Cassiopeia, midway between the point overhead and the western horizon. Cetus is south-west.

There is one more detail in this legend pictured among the stars, for it is said that from the blood of Medusa sprang Pegasus, the wondrous white-winged horse.

Close to Andromeda and facing west is the constellation Pegasus, outlined by four bright stars, one of which, known



THE MAGIC HORSE

by the Arabic name Alpheratz, serves a double purpose, for it also marks the head of Andromeda. Follow the two bright stars in Andromeda (see chart on p. 227) as a guide, and they point upward to Algol in Perseus. Only a part of the figure of a horse appears, and, moreover, it is always represented reversed, with the forefeet pawing the sky. For this horse was immortal and could fly with

the speed of the wind. From time to time he visited the earth to drink of the cool waters of a spring that had bubbled from the spot where his hoofs had first touched the earth, and this legend appears in a modern dress in Longfellow's poem, "Pegasus in Pound," which describes the magic horse paying an unexpected visit to a quiet New England village, and being put into the pound.

And the curious country people,
Rich and poor, and young and old,
Came in haste, to see this wondrous
Wingéd steed, with mane of gold.

. . . . .

On the morrow, when the village
Woke to all its toil and care,
Lo! the strange steed had departed,
And they knew not when or where.

But they found upon the greensward,
Where his struggling hoofs had trod,
Pure and bright, a fountain flowing
From the hoof marks in the sod.

BELLEROPHON AND PEGASUS

Pegasus was lent to Bellerophon, a Greek hero who was to attack a huge three-headed monster. The hero was successful, but in his pride he thought to fly to heaven on the winged steed. Jupiter in anger at this boldness sent an insect to sting the steed, and as a result Bellerophon was flung to Earth and Pegasus was placed among the stars.

On a clear starlit night, a glance at the space in the sky to the right of the stars of Pegasus, and above the bright star Altair in the constellation of the Eagle, will reveal a little group of stars known as the Dolphin. It is easily found on account of the four stars which mark the head, and are so arranged as to form the outline of a

diamond. Perhaps the four are better known as ' Job's Coffin,' though why that name was given is not known. The four stars are faint, and require a little patience before they are found, but when they are located it is easy to trace the remainder of the outline with the unaided eye, showing the three stars forming the tail of the dolphin.

ARION AND THE DOLPHIN

According to Greek mythology the dolphin was placed among the stars because he saved the famous poet and musician Arion from drowning when he was thrown overboard by the sailors on a ship in which he had embarked on his way homeward to Lesbos. The sailors did this cruel thing in order to rob him of a large sum of money which he had earned on his travels. Arion pleaded in vain for his life, but was given permission to play a tune upon his lute before he was put to death. The melody attracted a number of dolphins, one of which carried him safely on its back to land. Thus, as Hesiod quaintly describes it,

a dolphin's arched back
Preserved Arion from his destined wrack.

CHAPTER XIX

STORIES OF ORION AND THE PLEIADES

First next the Twins, see great Orion rise,
His arms extended stretch o'er half the skies.
His stride as large, and with a steady pace
He marches on, and measures a vast space;
On each broad shoulder a bright star displayed
And three obliquely grace his hanging blade.
In his vast head, immersed in boundless spheres
Three stars, less bright, but yet as great he bears,
But farther off removed, their splendours lost;
Thus grac'd and armed he leads the starry host.

MANILIUS

FROM the beginning of astronomy, probably long before this science was thought of, the stars of Orion were supposed to outline the figure of a giant. To some he was a hunter, a sort of celestial Nimrod, and to others he was a warrior. He is shown in the ancient picture-charts wielding an immense club in his right hand, and with a shield in his left. The star Betelgeux, a name derived from an Arabic word meaning ' giant's shoulder,' is the epaulet on his right shoulder, and Bellatrix, or ' the Amazon star,' adorns the left. The three stars which " grace his hanging blade " point downward to Sirius, the bright Dog-star named after one of his hunting dogs (the other, Procyon, being in Canis Minor).

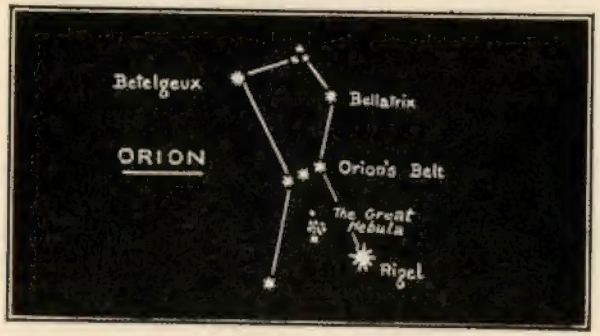
Orion was the son of Neptune and Queen Euryale, a famous Amazonian huntress. Possessing the daring disposition of his mother he became the greatest hunter in the world. As we have already seen, he was punished for his vanity by Juno, who commanded the Scorpion

to sting the foot of the mighty hunter, thus causing his death.

Below Orion's feet the Hare
Is chased eternally, behind him
Sirius ever speeds as in pursuit
And rises after, and eyes him as he sets.

ARATUS

We can scarcely suppose that the timid hare was the sole prey pursued by so great a giant and two such fine dogs. Seen in northern latitudes it seems to crouch low



THE MIGHTY HUNTER

on the horizon as if trying to escape the keen eyes of the hunter. That it is wounded we can well imagine if we look at the variable star R. Leporis. To see this star, however, at least a three-inch telescope will be needed. A line from Bellatrix through Rigel, which marks the right foot of Orion, points to it, and there is no mistaking this crimson star, with which no other compares in depth of colour. It has been likened to "a drop of blood on a black field," which carries out the legend in a very realistic way.

Orion seems to be warding off the attack of Taurus the Bull, which glares at him with its ruddy eye Aldebaran. It is interesting to compare the rosy colour of this star with the orange hue of Betelgeux, the bluish-white of

Rigel, and Sirius, which seems to flash with all the colours of the rainbow when close to the horizon.

Orion is a mine of wonders, the greatest being a little cloudy wisp—as it appears when seen with an opera-glass—which clings round the middle star of the three in the sword. When photographed, this hazy mist—a ghostly bat flitting through the night, it has been called—is shown to be a vast cloud of gaseous matter out of which stars are being fashioned, though centuries may elapse before these new celestial gems will be perfected. [1]

ORION AND THE HARE

Some one has said that there is no poetry or romance within the walls of an observatory, but I can remember one wonderful night when a great telescope had been turned in the direction of this vast nebula of Orion, and I could feast my eyes on its beauties while the astronomer—the late Professor Barnard—explained their meaning. "We might watch carefully for years," he said, "but no change would seem to take place; yet in reality this cloud is a seething mass of gaseous matter, whose bulk exceeds that of our Solar System millions of times, and within which motions at the rate of several miles a second are taking place."

To watch these atoms drawing in from space, "asserting their perpetual right to dance, in a universe of dust," let us mount the Time Machine, and turning the lever to the remote *Past* watch the atoms of the hydrogen and other gases of this nebula gradually drawing together in a vast

[1] See illustration facing p. 257.

cloud, the particles colliding and blending with one another like drops of water in a breaking ocean wave.

Turning the lever to the *Future*, we should probably gaze on a wondrous cluster of stars, the final result of this turmoil and work during centuries of time, the finished gems varied in colour as the tints of the rainbow, the newer stars just leaving their cradles of star-mist with gaseous tendrils still clinging around them.

Others born in earlier ages already rank as giant stars. Betelgeux, for instance, whose diameter has been measured at Mount Wilson Observatory, is so vast that if it were placed on the Sun, its rim would overlap all round to a distance almost as far as the orbit of planet Mars. Its diameter is no less than two hundred and fifteen million miles! Compared with Betelgeux, therefore, the Sun—our special Day Star, is merely a dwarf. And so the stars are divided into giants and dwarfs which move and have their being in a story as wonderful as any we read in the pages of *The Arabian Nights*.

It will help you to realize the vastness of Betelgeux if I tell you that a bullet fired from a rifle—if it could circle round the star (ignoring the law of gravity)—would return to the spot from which it had been discharged in fifty-six years!

The great nebula in Orion has been known to astronomers for three centuries, and photography has revealed the presence of a spiral of nebulous matter sending its tendrils nearly over the entire constellation. Photographs taken during three hours' exposure with the great 100-inch mirror at Mount Wilson Observatory (which is large enough to collect 160,000 times the light received by the eye), have revealed a curious dark mass. This is south of the third and lowest star in the belt of Orion, and in the photographs it looks very much like a horse's head. In fact, it is sometimes referred to by that name. It seems to be a great cloud of dust which may later form into stars; or it may be the *débris* of

stars which have burnt out like cinders, and which no celestial bellows can revive.

Probably the story of the Pleiades, or Seven Sisters, is as well known as that of the Great Bear, for nearly every nation has its legend concerning them. To the Greeks they were the seven beautiful daughters of Atlas and Pleione. Their names are Merope, Alcyone, Celæno, Electra, Taygeta, Asterope, and Maia. It is said that the hunter Orion pursued them across wood and dale until they called upon Jupiter to come to their rescue. He heard their cry and is said to have changed them into doves, later on placing them among the stars. The seven stars are actually drifting eastward in the direction of Orion instead of away from him, so that he is no longer the pursuer.

THE PLEIADES

There is a legend of a lost Pleiad, which some say is Electra, who hid her face at the burning of Troy. She, however, has apparently recovered from her fright, as she now shines as brightly as her sisters. Others say it is Merope, whose light is dim because instead of marrying a god, like her sisters, she was wedded to a mortal, Sisyphus, King of Corinth.

According to the Greeks, the Pleiades "were like doves who carried ambrosia to Zeus, but always one got lost in passing the Planctae rocks, and always Zeus made their number up again to seven."[1]

But the star-mist which veils the light of Merope is also seen enveloping the other stars in the group, recalling the well-known lines of Tennyson:

[1] *The Night-Skies of a Year*, by Joseph Elgie, p. 146.

Many a night I saw the Pleiads rising through the mellow shade,
Glitter like a swarm of fireflies tangled in a silver braid.

The Iroquois Indians tell the story of a little Indian boy who was placed in the sky with his six brothers. The poor child was homesick and did not want to be a star. He cried bitterly and as he wept he covered his face with his hands ; this is why his light is dim. The story as I heard it in America was told to me as follows by Miss Mary Owen, of folk-lore fame, and is quoted from my book, *Stories of Starland*.

" Seven little Indian boys lived in a log cabin in the woods, and every starlight night they would go out on the top of a mound, and, joining hands, dance in a ring as they sang the *Song of the Stars*. The stars looked down on them and twinkled, meaning in starry language, ' We would like you to come up here,' but the little boys were quite happy in their own home on planet Earth.

" However, it happened one evening when they came home after a jolly romp in the woods, chasing 'possums and running races with each other, that they felt very tired and ravenously hungry. There were no corncakes for supper that night, and whatever it was their mammy placed on the table, it was not to their liking, so they left it untouched. With lagging steps, they went out to the top of the mound and began to dance, and their song was not as merry as usual. Therefore, when the stars beckoned to them to come up to the sky, they accepted the invitation without delay. There they can be seen on any clear night, even the homesick boy star, if you look for him with an opera-glass."

In an *Easy Guide to Southern Stars*, by M. A. Orr (Mrs Evershed), is the legend told by the Australian natives, who believe that the seven stars are six attendants with their beautiful queen. Waa, the Crow (Canopus), disguised himself as one of the white grubs of which the natives are very fond. When the queen and her attendants came seeking for grubs in the bark of the tree in

which Waa was hiding, the hooks of the maidens were broken, but when the lovely queen pushed her ivory hook into the hole, out came Waa, who instantly resumed his proper form and carried off the queen.

A South Sea myth about the Pleiades has it that the group was once a single star, which shone so brightly that it annoyed Tane, the god of the sky. With Aldebaran and Sirius he pursued the bright star and hurled Aldebaran at it, breaking it into seven parts.

To the ancient Greeks the appearance of the seven stars before sunrise on the 11th of May, about the time of harvest, announced the opening of the season for navigation, and they named them ' sailing stars.'

When, Atlas born, the Pleiad stars arise
Before the sun above the dawning skies,
'Tis time to reap ; and when they sink below
The morn illumin'd west, 'tis time to sow.
MANILIUS

Thus, in all ages these stars have been observed by sailors and farmers for signs of the seasons. Virgil tells us how the first mariners relied upon the stars to guide their rude barks over the seas. He tells how Palinurus, the pilot of the Trojan fleet, watching the stars,

The Pleiads, Hyads, and their wat'ry force,
And both the Bears is careful to behold.

Indeed, Palinurus was once so intent in gazing upon the stars while at the helm that

Headlong he fell, and struggling in the main,
Cried out for helping hands, but cried in vain.

From such constant watching the stars the modern science of navigation has sprung. Greenwich Observatory was founded by King Charles II in 1675 for the benefit of seamen. The Rev. John Flamsteed was appointed the first ' Astronomer Royal,' and as the King's astronomer he was " to apply himself with the most exact care and diligence to the Rectifying the Tables of

the Motions of the Heavens and the Places of the Fixed Stars, in order to find out the so much desired longitude at Sea, for the perfecting the Art of Navigation."

The chief work of the Observatory is to observe the motions of the Sun, Moon, and planets, and to issue reliable star catalogues. Its most important service is to register accurate time, essential to science and also required more and more in industry and commerce. Railways and telegraphs demand that as far as possible a country should keep one standard time throughout. A great part of the civilized world bases its time on 'G.M.T.,' that is, Greenwich Mean Time, the meridian[1] of Greenwich having been adopted as the standard for general use. Time signals are sent out daily to the London General Post Office and transmitted daily or hourly over the telegraph system to every post office throughout the land. This time service controls public clocks or is made to drop public time-balls where local authorities provide the small outlay necessary to give their cities accurate time.

Wireless telegraphy has made possible a remarkable extension of this time service. At stated times, both by night and day, the wireless stations at the Eiffel Tower in Paris send out time signals. For instance, the hour is signalled to ships at sea at 11 A.M., and at midnight time signals are sent out by sparks which reach ships 2,500 miles away, even as far as the coast of Australia, since they can be transmitted all round the world. The wireless station at the Eiffel Tower in Paris has been fitted with apparatus for wireless telegraphy, and wireless telephonic communication has been established as far as New York. Since July 1st, 1913, the time signals transmitted by all wireless stations are identical.

According to the system now established in the United States, there are five standard times in use—the colonial,

[1] A meridian is an imaginary circle round the earth in a north and south direction, passing through the poles.

NEBULA IN CYGNUS

THE SPIRAL NEBULA IN THE GREAT BEAR

Views taken with the 60-inch reflector at Mount Wilson Observatory by Professor G. W. Ritchey

RECEIVING WIRELESS TIME-SIGNALS AT THE OBSERVATORY OF PARIS
Photo Jacques Boyer (Underwood Press Service)

eastern, central, mountain and the Pacific—which differ from Greenwich time by exactly four, five, six, seven, and eight hours respectively, *the minutes and seconds being identical everywhere.* In order to determine the standard time by observation, it is only necessary to compare the local time and correct it according to the observer's longitude or distance east or west from Greenwich.

Arrangements have been made for transmitting the time signal of the British Broadcasting Company directly from the Greenwich Observatory to all parts of the British Isles. These were first brought into operation on February 4th, 1924, when the Astronomer Royal, Sir Frank Dyson, gave a ' wireless ' address, and explained the origin of time signals and the international arrangements that have been adopted for their standardization.

Wireless time signals during the period August 1922-23 were received at Greenwich from the Eiffel Tower, Nauen, Bordeaux, and Annapolis, and from Moscow during the winter months.

One of the most powerful wireless stations in the world is situated at Arlington, near Washington, D.C. It has a sending range of over 3,000 miles. Every day at noon wireless time signals are sent out so that every ship that is fitted with wireless apparatus can get the correct time.

But where does the day begin ? Let us imagine that you are starting from Greenwich on Monday at noon, and journeying westward as swiftly as the Earth turns to the east under your feet. You would, of course, keep the Sun exactly on the meridian all day long, and have continual noon. But what noon ? It was Monday when you started, and when you get back to Greenwich twenty-four hours later, it is Tuesday noon there, and there has been no sunset in between. When does Monday noon become Tuesday noon ? The change of date occurs at the 180th meridian from Greenwich.

Ships crossing the line that day from the east slip one day in so doing, and if it is a passenger steamer Father Neptune comes aboard and there are great festivities. It is Monday forenoon when the ship reaches the line, and it becomes Tuesday forenoon the moment it passes it, the intervening twenty-four hours being dropped from the reckoning on the log-book. When a ship crosses the line from the western side, it counts the same day twice, passing from Tuesday forenoon back to Monday, and having to do its Tuesday over again. The 180th meridian passes mainly over the ocean, hardly touching land anywhere.

CHAPTER XX

LEGENDS OF THE SILVER RIVER OF HEAVEN

Stars which stand as thick as dewdrops on the field of heaven.
BAILEY

IN ancient times the Milky Way, or Galaxy, that

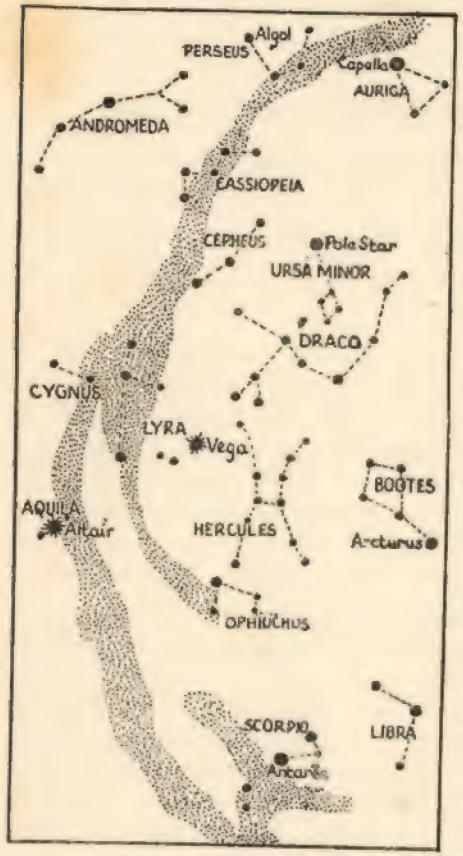
> . . . broad and ample road, whose dust is gold,
> And pavement stars,

as Milton, in *Paradise Lost*, calls it, was supposed to lead directly to the throne of Jupiter. Beside the road stood the palaces of gods, while the lesser people of the skies dwelt on either side of the golden pathway. The Greeks, in whose clear skies it is seen in its full glory, connected it with the unfortunate Phaeton who attempted to drive the chariot of the Sun. It was, they said, the fiery track along which the runaway steeds bolted when they swerved from the pathway of the Sun, thus setting the heavens on fire and nearly causing the destruction of the Earth.

The Chinese regard the Milky Way as a celestial river and account for its disappearance when the Moon appears as a crescent by the legend that the silvery fishes hide themselves beneath its waves affrighted at the shape of the crescent, which suggests a hook. To the Japanese the Milky Way is the silver river of heaven, curiously connected with the constellations of Lyra and Aquila in the legend of the Spinning Damsel and the Magpie Bridge, which is as follows :

A youthful herdsman driving an ox passed the Spinning Damsel one day while she sat at her loom on the banks of the silver river and instantly fell in love with her. She

had the pleasant task of weaving the rosy colours of dawn and the silvery twilight fringe which adorns the border of the mantle of night. From the moment she saw the youth the maiden neglected her work, so that the dawn and twilight hues lost their beauty.



THE STAR-LOVERS

The Sun, the father of Tanabata the Spinning Damsel, angry with the young herdsman because in his lovesickness he allowed his ox to wander at large over the High Plain of Heaven, banished him to the opposite bank of the Milky Way, where he shines as Altair in the constellation Aquila. Similarly the maiden is Vega in the constellation Lyra. Once a year the lovers are allowed to meet, and to do so they must cross the Milky Way. If you will look at the star-map you will see that there is a great gap in the silver river and the lovers meet in this gap half-way between the two constellations. Altair crosses from his side and Vega from her side, and the bridges over which they pass are formed by magpies. Woe betide a magpie which does not take part in this service to the celestial lovers.

The Silver River of Heaven

This story is the origin of the festival called Tanabata, after the name of the Spinning Damsel. In the legend the meeting takes place on the seventh night of the seventh month. If rain should fall that night the meeting cannot take place, because the heavenly river would become too broad to be spanned by the magic bridge. For this reason rain on Tanabata night is called the Rain of Tears. The Japanese firmly believe that the meeting of the star-lovers (represented by Vega in Lyra and Altair in the Eagle) can be observed by those with keen eyes, and when the constellation of the Eagle is seen low on the eastern horizon early in the evening the stars burn with all the colours of the rainbow. Lafcadio Hearn writes of the romance as follows :

> In the silence of transparent nights, before the rising of the moon, the charm of the ancient tale sometimes descends upon me. . . . I see the thrill of its shining stream, the mists that hover along its verge, and the water grasses that bend in the winds of autumn. White Orikimé I see at her starry loom, and the ox that grazes on the farther shore, and I know that the falling dew is the spray of the herdsman's oar.

The Norsemen also told of a queen who sat in the northern sky at her loom in the Hall of Mists, spinning golden thread, or weaving web after web of many-coloured clouds. They called her Frigga, and she was the wife of All-Father Odin.

In Sweden the Milky Way is ' the Winter Street,' and Miss Edith M. Thomas in the following poem tells us the meaning of the name :

> Silent with star-dust, yonder it lies,
> The Winter Street, so fair and white ;
> Winding along through the boundless skies,
> Down heavenly vale, up heavenly height.
>
> Faintly it gleams, like a summer road
> When the light in the west is sinking low,
> Silent with star-dust! By whose abode
> Does the Winter Street in its windings go ?

Book of the Heavens

And who are they all unheard and unseen—
  O, who are they, whose blessed feet
Pass over that highway smooth and sheen?
  What pilgrims travel the Winter Street?

Are they not those whom here we miss
  In the ways and the days that are vacant below?
As the dust of that Street their footfalls kiss
  Does it not brighter and brighter grow?

Steps of the children there may stray
  Where the broad day shines though dark earth sleeps,
And there at peace in the light they play,
  While someone below still waits and weeps.

According to another Swedish legend, which reminds us of the Japanese story, the Milky Way sprang from the love of two mortals who could not bear to be separated.

Far, far away, where heaven ends, he lived upon a star,
And she lived on another one, removed so far, so far!
They loved and longed but for the time they might united be,
And she was Salami the Fair, bold Zulamith was he.

And each thought of the other still in longing and in tears,
And while they sat and listened to the music of the spheres,
Those countless miracles of God—stupendous planets rolled
Between poor Salami the Fair, and Zulamith the Bold.

But Zulamith, with sturdy heart, one evening had begun
To build a bridge of light, to span the space from star to sun,
And Salami in loving faith, from her lone home afar,
She, too, began to build a bridge of light from star to star.

They toiled and built a thousand years in love's all-powerful might,
And so the Milky Way was built—a bridge of starry light,
Which now smiles down upon the earth from heaven's placid face
And firmly binds together still the shores of boundless space.

And Salami and Zulamith, when their long toil was done,
Straight rushed into each other's arms and melted into one.
So they became the brightest star in heaven's high arch that dwelt,
Great Sirius, the mighty sun, beneath Orion's belt.

From the Swedish of ZACHEUS TOPELIUS

GREAT RIFT IN THE MILKY WAY NEAR OPHIUCHUS 244

Photographed at Mount Wilson Observatory with the 60-inch reflector by the late Professor E. E. Barnard

[*See p.* 242]

FRIGGA SPINNING THE CLOUDS
J. C. Dollman
[See p. 243]

The Silver River of Heaven

The Norsemen believed that the Milky Way was the path along which the ghosts, or spirits of the departed, went to Valhalla, and the North American Indians also call it

> . . . the broad white road in heaven,
> Pathway of the ghosts, the shadows
> Running straight across the heavens,
> Crowded with the ghosts, the shadows.
>
> LONGFELLOW

To the Algonquin Indians it was ' the path of souls ' leading to the villages in the Sun, the bright stars along the edge of the Milky Way being camp-fires to guide the spirits on their journey to the happy hunting-grounds. Longfellow refers to this belief in *Hiawatha*, in the description of the journey of Chibiabos to the land of the Hereafter :

> Telling him a fire to kindle
> For all those who died hereafter,
> Camp-fires for their night encampments,
> On their solitary journey
> To the Kingdom of Ponemah,
> To the land of the Hereafter.

The Peruvians termed the Milky Way ' the dust of the stars,' the Eskimos call it ' the path of the White Ashes,' and in Northern India it is said to be ' the path of the Snake.'

In olden times the inhabitants of Britain called it ' Watling Street ' ; in Wales it was ' the silver street leading to Caer Groydon,' the castle where dwelt the King of the Fairies. There are many more such legends about this pathway " powdered with stars."

> Look how the floor of heaven
> Is thick inlaid with patines of bright gold.
>
> *Merchant of Venice*

Far more wonderful are the facts, for each grain of that star-dust is a mighty sun, perhaps exceeding in size

and splendour the Sun that governs the system to which our planet belongs. For all we know, these distant suns may be pouring light and heat on little families of planets with their attendant moons. It has been calculated that there are millions of stars in that faint band of light which spans the northern sky, but which is aglow with light when seen in southern skies.

When we look at it with a telescope we find that the stars are arranged in streams and rows, in coronets and festoons, upon the black robe of night. Nor are varieties of colour wanting to render the display more wonderful and beautiful. Many of the stars which crowd upon the view are red, orange, and yellow, forming a charming contrast to blue, green, and lilac stars near by. And, moreover, all these stars are in rapid motion, darting to and fro, like motes in a beam of sunlight.

Is it surprising, then, that sometimes collisions occur and new stars blaze into view, fading again as their light dies down, like an expiring ember? Or perhaps one of the dark stars may plunge into the gaseous mist in that region, and just as a meteor suddenly blazes out from friction with the particles in our atmosphere, so the dark star dashing into the mist flashes into an intense heat, delighting us for a brief time with its splendour, but disappearing ere long for ever.

Imagine the millions of eyes and the many telescopes and cameras which are turned in the direction of such a stranger and the delight of the fortunate mortal who is the first to observe it. For this reason it is worth while to know the bright stars, that is, those that can be seen without the assistance of a telescope. You may be walking along some fine evening and you look up at the sky at your old friends—it is to be hoped they are your friends—and you see a stranger in their midst. There is no star in your star-chart marking that special part of the sky and you hurry home, look at your chart and again at the star, and being quite sure you telephone to

the nearest observatory, where astronomers are always on guard at night, and report that you have seen a bright star which you have never seen before, and that it is in such and such a constellation. If the flare-up is anywhere in the Milky Way you may feel certain you have made a discovery; it is only in or very near that region of the sky that such celestial events have been known to occur.

In case you are not quite sure of the course pursued by the Milky Way, it can be easily found, as the most brilliant constellations lie either in it or along its borders. It winds in and out among the stars of Cassiopeia's chair, on which she is seated, across the silver stream. Perseus is enwrapped in a mantle of its stars, which glisten on the tips of the horns of Taurus.

The silver river flows at the feet of Gemini, the Twins, and near the head and shoulders of Orion, and Sirius glows on its bank like a beacon light. "In the Southern Hemisphere," to quote from Mr Serviss, "we should find the beautiful constellation of the ship Argo, containing Canopus, sailing along the Milky Way, blown by the breath of old romance on an endless voyage; the Southern Cross glitters in the very centre of the Galaxy and the bright stars of the Centaur might be likened to the heads of golden nails pinning this wondrous scarf, woven of the beams of millions of tiny stars, against the dome of the sky." Passing northward again, we find the Scorpion with its glowing Antares, pursued by Sagittarius the Archer. Aquila, the Eagle, and Lyra, with its resplendent star Vega, and the stars outlining Cygnus the Swan, which lie across the Milky Way, are among the most brilliant objects in that part of the sky.

Could we withdraw into the depths of space to a distance so great that the Sun-star would dwindle to a point, the Milky Way would appear as a spiral-shaped ring encircling all the bright stars we can see in our part of the Universe. We should find ourselves in a region where there are many such spiral-shaped clouds of gas.

The Time Machine would enable us to watch them unfolding with the speed of many miles a second, like giant Catherine-wheels. It is only by means of photographs exposed for hours that we have learned about these far-distant spirals, which number many thousand. Maybe these are other universes like our own, but in each, as in every atom of space, the great law of gravity governs and controls, so that order and harmony reign supreme.

CHAPTER XXI

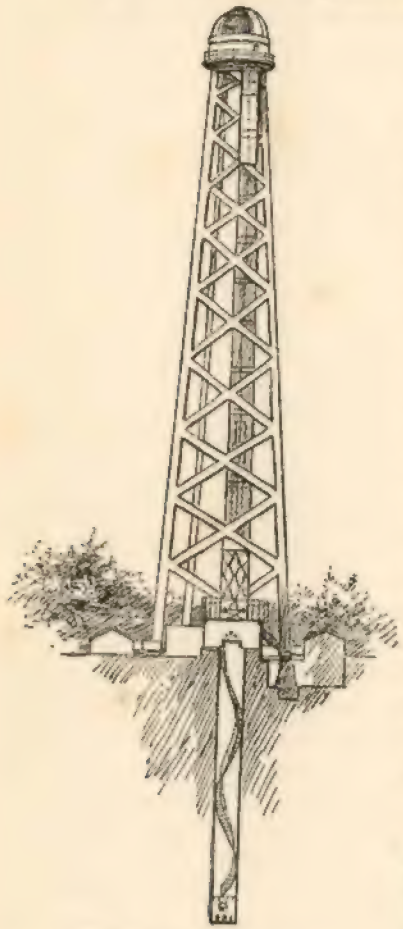
MOUNT WILSON OBSERVATORY AND THE SPECTROSCOPE

MY first visit to Mount Wilson Observatory was in 1910, but it was a mere passing call, and in 1911 I made arrangements to spend a week on the mountain summit, where bungalows are provided for occasional visitors. On the morning I started from Los Angeles the sky was cloudy, but by the time I was halfway up Mount Wilson I was able to look down on the billowy clouds which almost hid Los Angeles and Pasadena from view. At the same time I became uncomfortably aware of the fact that I was exposed to the glare and heat of the noonday Sun.

Every now and then I would pass a huge white stone telling the number of miles still to be climbed (for the track is seven miles in length) before I could reach the Observatory heights, and on large, white-faced rocks I read the legend, "Now Smile," which had a bracing effect. Those who have climbed the six thousand feet know how trying it is, but I was told that the assistants thought nothing of making the double journey the same day providing they started at about six in the morning.[1] Arrived at the summit I made my way to the hotel, for this region is a favourite summer resort for tourists, and during the winter months, when there is sunshine in the valley, the snow on the mountain tops is an invitation to winter sports. The snow is sometimes two or three feet

[1] It is now possible to make the trip by auto-stage, for which purpose the road has been considerably widened. The distance from Pasadena to the summit of Mount Wilson is covered in 2½ hours.

deep, and photographs taken of the Observatory buildings during the month of January might well convey the idea that it is an Arctic scene.



THE TOWER TELESCOPE

After making arrangements for a bungalow I made my way toward the Observatory, when I met a beautiful St Bernard dog, Solar. He was an excellent sentry for keeping unwelcome visitors away, but he seemed to approve of me, for he led the way and I followed to the great dome containing the reflector. This has a mirror or reflector 60 inches in diameter, at that time (1911) the largest in the world. The lens of the human eye is at the most about one-quarter of an inch in diameter, and the 60-inch reflector has an area 57,600 times that of the eye. The later reflector in the new dome collects 160,000 times the light received by the eye.

At the time of my visit men were at work upon a clearing for the new Observatory building to house this powerful instrument, and today the two great reflectors are used night after night to gather news of the heavens from the messages of starlight which imprint themselves upon the delicate photographic films. In these star-imprinted records new wonders have been revealed, such

as detailed structure in the spiral nebulae in which new universes are to be seen in the making, and no other observatory has made such exhaustive studies of the Sun as those obtained with the spectroheliograph [1] in the tower telescope near by. These have enabled the astronomer to learn wondrous facts about the mighty whirlpools on the Sun, and to peer—as it were—into the upper layer of hydrogen clouds in its atmosphere, as well as at the calcium clouds in the lower layer which so closely resemble clouds adrift in a terrestrial valley.

One evening it was my privilege to look through the great 60-inch reflector at some of the wonders of the heavens, a cluster of stars,[2] glistening points of light which seemed to be outlined against a soft, misty haze, through which glowed the faint light of still more distant stars :

> Isles of light and silvery streams,
> And gloomy gulfs of mystic shade,

to quote the well-known lines by Tennyson.

Another of the wonders of the Mount Wilson Observatory is the tower telescope, already referred to, a tube 150 feet high, supported by a framework of steel girders and roofed by a dome of steel. The solid rock at its base has been excavated 78 feet deep, so that from the top to the bottom there is a shaft about 228 feet in length.

When I asked Professor Adams how the dome was opened each morning, as I could see no machinery or visible means of ascent, he invited me to step into a kind of giant bucket which I had not noticed, and in which two assistants had just then taken their places. In a moment we were speeding upward on the outside of the tube but within the framework as smoothly as in a lift,

[1] The word ' spectroheliograph ' is derived from the words *spectrum*, colours shown by the prism ; *helios*, the sun ; *grapho*, I write—meaning that the sun by photography records what is borne on the rays of light.

[2] See illustration of a star cluster facing p. 169.

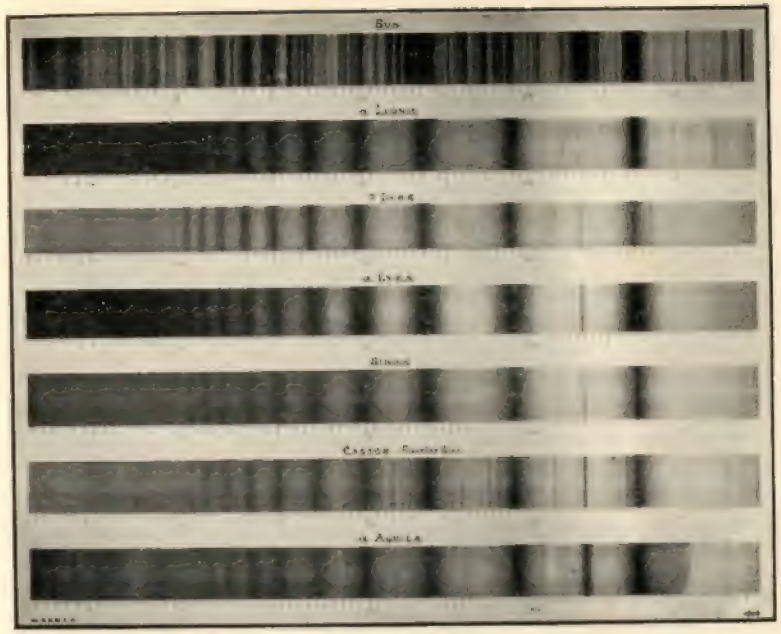
and I had some faint idea of what an ascent in an aeroplane might mean.

When we arrived at the top we stepped on to a platform, and an assistant opened the dome. Inside, I saw two great mirrors, one facing the Sun, and the other set at an angle to reflect the beam downward through a lens and tube to the prisms in the interior of the rock far below. The first mirror is driven by clockwork, and the image of the Sun formed by the lens is sixteen inches in diameter.

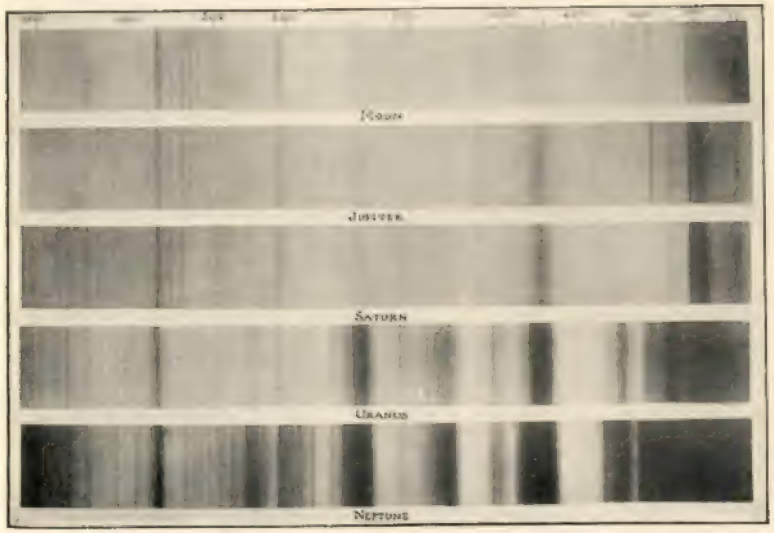
Returning in the bucket, Professor Adams invited me to make the descent into the pit below by means of a spiral staircase at the side of the wall. At the bottom of the well I saw a table and on it a Rowland grating. This consists of a polished metal concave surface six inches wide, on which thousands of equally spaced lines had been ruled with a machine specially made for this purpose. I was told that the grating contained 14,468 lines to the inch, or, in all, 86,808. These replace a prism in an ordinary spectroscope used for dispersing sunlight. Looking up, I saw the image of the Sun on the mirror in the dome far above, and it seemed to be suspended in the sky. The main value of the well is that its temperature is nearly constant, a most important condition where instruments of great delicacy are concerned.

Climbing to the surface level I found another treat awaiting me, for I was invited to look back into the well through a narrow, very narrow, slit in the huge spectrograph,[1] and with the assistance of a magnifying glass, I beheld a most wonderful sight. Picture to yourself a vivid rainbow, caused by the sunlight reflected from the mirror in the dome shining down upon the grating below, and spread out in a gorgeously coloured band, thus aptly described by Thomson :

[1] The spectrograph forms part of what is actually a greatly lengthened vertical spectroscope mounted in the deep well beneath the tower. With this powerful instrument lines which with the standard prism spectroscope appear to be hardly separated are shown about 1.2 inches apart.



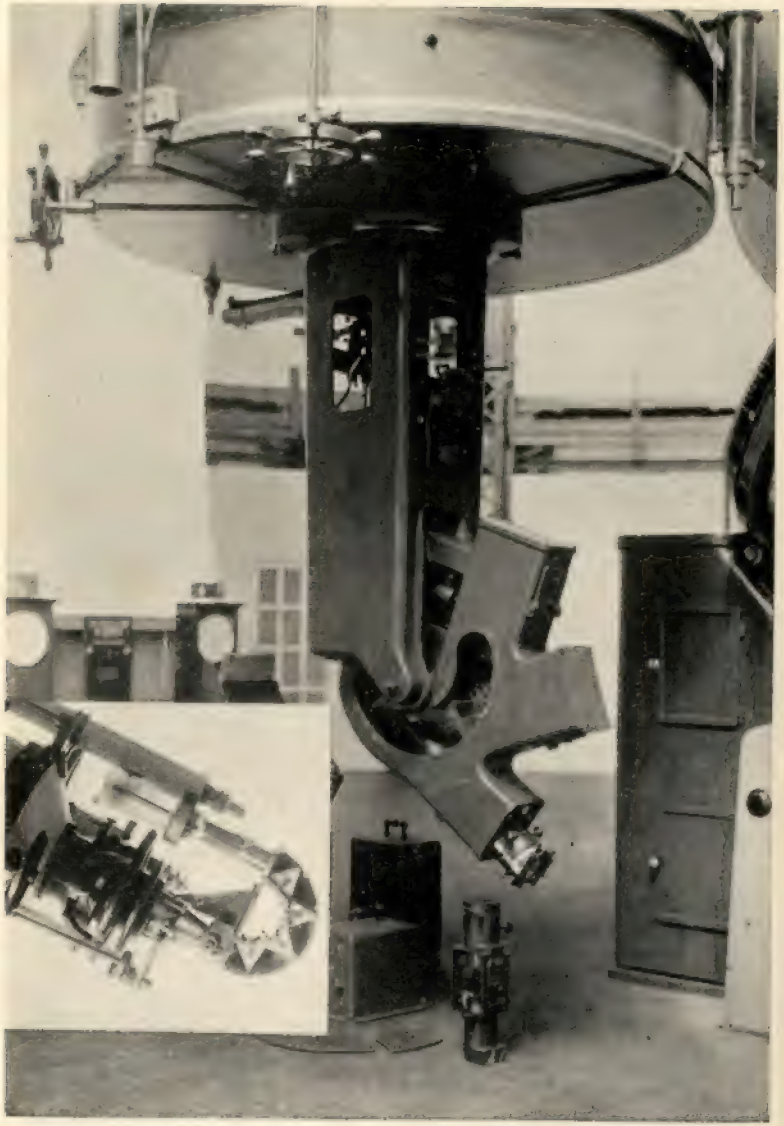
SPECTRA BANDS OF SUN AND VARIOUS STARS



SPECTRA BANDS OF THE MAJOR PLANETS

Photographed at Lowell Observatory, Flagstaff, Arizona

[See p. 257]



THE 72-INCH REFLECTOR AT VICTORIA OBSERVATORY, BRITISH COLUMBIA

The inset shows the four-prism spectrograph of the Newell Telescope at Cambridge

[*See p.* 257]

Mount Wilson Observatory

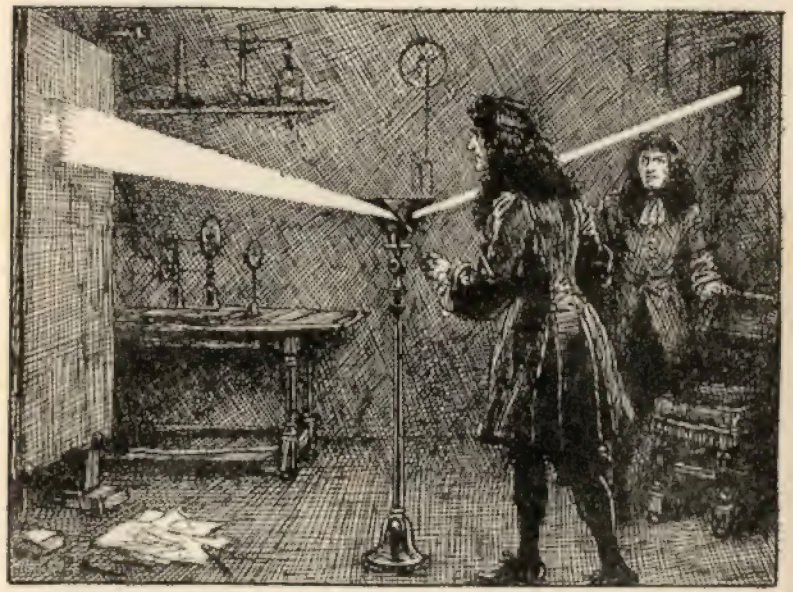
First, the flaming red sprang vivid forth,
The tawny orange next, and then delicious yellow,
By whose side fell the kind beams of all-refreshing green.
Then the pure blue that swells ethereal skies.
And next, of sadder hue, emerged the deeper indigo,
As when the heavy-skirted evening droops with frost,
While the last gleamings of pale refracted light
Died in the fainting violet away.

I thought of the old fable about the crock of gold that awaits him who digs in the ground where the rainbow ends; but although no crock of gold awaited me, I seemed to be literally at the end of the marvellous rainbow.

One day when the great philosopher Sir Isaac Newton was experimenting with a ray of sunlight and a prism, that is, a piece of glass with three sides to it, he made a wonderful discovery. He found that the ray after passing through the prism was reproduced on his screen as a bright rainbow-coloured band. When the prism was removed, a bright spot of the same shape as the hole in the shutter through which the ray was admitted was seen on the screen. Now why was the light spread out into a long rainbow-coloured band when it had passed through the prism? It was not until after much patient work that Newton solved the problem. He discovered that though a beam of light looks white, yet in reality it is composed of differently coloured lights blended together. The prism disentangles them, like skeins of coloured silk, and Newton found, moreover, that the rays at the blue end of the band or spectrum are bent most by the action of the glass, while the rays at the red end are bent least.

The rainbow colours—violet, indigo, blue, green, yellow, orange, and red—which the prism reveals are contained in the seemingly white shaft of the sunbeam, and the prism merely separates the ray of light into the seven colours of which it is composed. We see these colours, also, in the rainbow, in soap-bubbles, or in dewdrops glistening on blades of grass when the Sun shines upon them.

These tiny messengers from the Sun and stars tell us many wonderful secrets as we unravel their skeins of light and test them in our laboratories. Just as a chemist can tell what a substance is made of by submitting it to various tests, so can an astronomer find out by means of



SIR ISAAC NEWTON'S DISCOVERY OF THE PRINCIPLE OF THE PRISM

the spectroscope what the Sun and stars are made of, although he cannot journey to the Sun and stars for samples of their matter. By means of a prism or grating he can break up a beam of sunlight into its rainbow colours, and see, instead of one round white image of the Sun, an immense number of images of different colours. To prevent overlapping and confusion, he makes the beam fall through a narrow slit before it reaches the prism, and then the images are all narrow and straight lines (like the slit), lying side by side, so many and so close that they form an almost continuous band. But in

many places this coloured band is interrupted by fine *dark* lines, and the meaning of these lines has been discovered, so that astronomers can now read in them the secrets of Sun and stars.

The lines are known as the Fraunhofer lines in honour of the discoverer, Joseph von Fraunhofer, a noted German optician of Munich, who was born in 1787. In July 1801 two old houses in an alley of Munich tumbled down, burying in their ruins the occupants, of whom only one was taken out alive, though seriously injured. This was Fraunhofer, then an orphan lad of fourteen. The Elector Maximilian Joseph was witness of the tragedy, and out of pity for the survivor he made him a present of eighteen ducats.

Fraunhofer spent part of this sum in books and a glass-polishing machine, with the help of which he studied mathematics and optics and taught himself how to shape lenses. The remainder of the money purchased his release from a looking-glass maker to whom he had been bound apprentice on the death of his parents. He had a hard struggle to make a living and at the same time fit himself for the optical work in which he became so deeply interested.

In the course of his experiments on lenses he looked through a small telescope at a ray of sunlight passing through a slit and a prism, and saw the dark lines which we have described. Of these he counted six hundred, and carefully mapping 324 he named the most noticeable after letters in the alphabet, A to H. The letter A occupied a position in the extreme red, B and C were also in the red, D in the yellow, followed by E, F, and G in the green, blue, and indigo, while H was in the extreme violet. But neither he nor anyone else knew the meaning of these puzzling black lines. He examined starlight in the same way, and found that although the colours of the bright band always follow in the same order, the dark lines vary much in number, width, and darkness, from star to star.

It was not until nearly fifty years later that the problem was fully solved, by another German named Kirchoff. He found that the positions of the dark lines in the spectra of Sun and stars correspond so exactly with the bright lines of glowing sodium, iron, calcium, hydrogen, and many other substances found on Earth, that there can be no doubt these exist in Sun and stars. The lines look dark only because the gases which produce them are near the surface of the heavenly body, and are cooler than the immensely hot gases below them, which make up its mass and produce the bright continuous band of the spectrum.

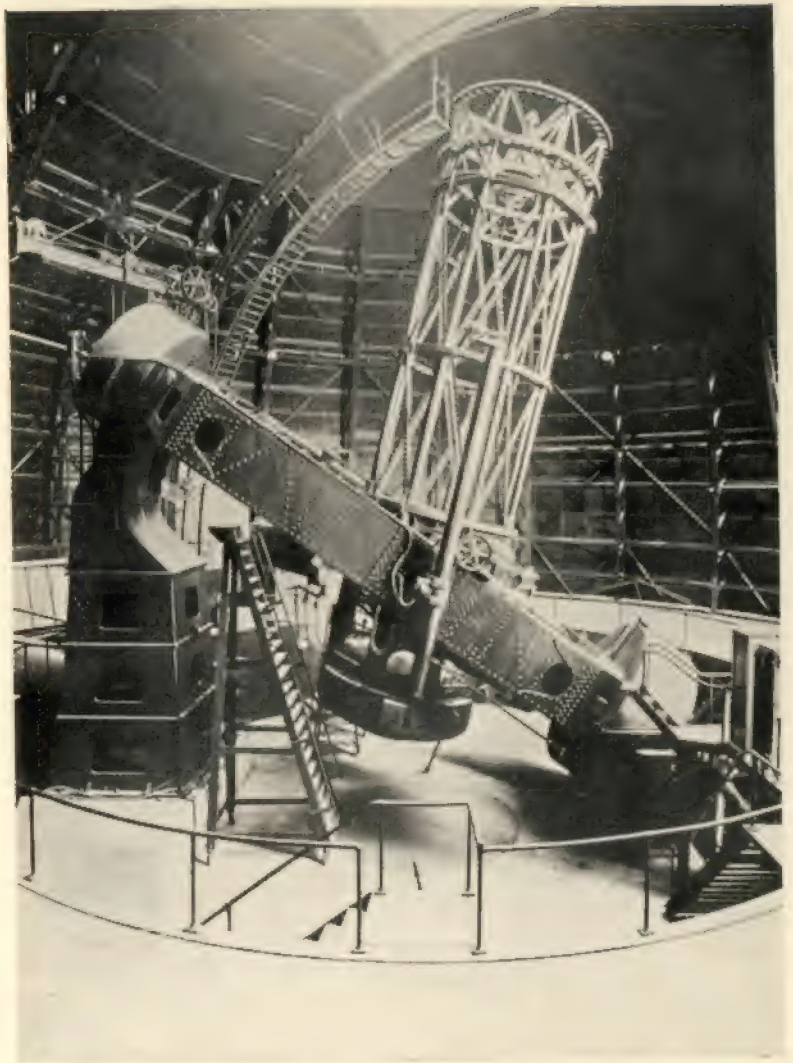
Thus the astronomer with our magic glass, the spectroscope, sifts out the waves of light. Just as a chemist can take some substance, such as barium, magnesium, or sodium, and melting it in the intense heat of an electric spark, can throw its light into the spectroscope, and by its lines actually read what metals or non-metals it contains, so from a tiny shaft of starlight the astronomer can tell what a star is made of, though it is billions of miles away. You may have read those lines, quoted by Sir R. S. Ball in *Starland*:

> Twinkle, twinkle little star,
> Now we find out what you are,
> When unto the midnight sky,
> We the spectroscope apply.

This magic glass not only tells us what the stars are made of, but whether they are approaching or receding, their rank in stellar grades as giants or dwarfs, the speed of the whirling spirals, and even what it is like inside a star. These wonderful light-messages make us realize the true meaning of those lines by Pope:

> We are but parts of one stupendous whole,
> Whose body Nature is, and God the soul.

A friendly rivalry exists between the staffs of the Observatories at Mount Wilson and of the one recently



THE 100-INCH REFLECTOR AT MOUNT WILSON OBSERVATORY

THE GREAT NEBULA IN ORION
Photographed at Yerkes Observatory
[See p. 234]

erected at Victoria, British Columbia, as to which telescope shall do the most effective work. It is true the one has a mirror one hundred inches in diameter, and the other but seventy-two inches, yet the photograph of the great cluster in Hercules taken with the latter has so far been unsurpassed. The telescope, however, is used chiefly for finding the speed of the stars by means of a spectrograph attached to its lower end.

There is an interesting story told in connexion with the seventy-two inch mirror. The glass for it was made at Charleroi, Belgium, and completed just before war was declared in 1914. The news of the completion was cabled to the Director of the Observatory, at Victoria, B.C., who cabled an order that the glass should be forwarded at once. The mirror reached its destination in safety, and the telescope was ready for work in July 1916. Had not the order been instantly obeyed the mirror would never have left Belgium, as the glass-works at Charleroi were bombed and utterly destroyed after war broke out.

The illustration facing p. 252 shows us the appearance of spectra bands of some of the stars and of the Moon and major planets. Of course the light which the planets send to us, and which is dissected in our spectroscopes, is not their own. They shine with a radiance borrowed from the Sun, but nevertheless astronomers learn important things about the nature of their atmospheres, etc., from these rays of light.

As regards the stars, there is hardly a physical or chemical property which the astronomer cannot discover from the spectra bands. The aid he has received from them during the past sixty years or so has enabled him to penetrate deeply into fields of profound knowledge which were entirely barred to his predecessors.

After a week filled with wonderful experiences I returned to Pasadena, where I met Mr John Daggett Hooker, who invited me to visit his library so that I

might see what he called an electro-transparency. This was an arrangement of sixteen electric bulbs fixed behind a wooden screen with open sections, in which were placed glass transparencies of the wonderful photographs taken with the Reflector at Mount Wilson.

Mr Hooker was specially interested in a photo of the great nebula in Orion, which he told me was his favourite. While looking at this one evening he became so enthusiastic that he wrote to the Carnegie Institution at Washington offering the sum of fifty thousand dollars for the purchase of a hundred-inch mirror for a greater telescope to be erected on Mount Wilson.

The gift was accepted, and the order for the casting of the great disk was given in September 1906 to the French Plate Glass Companies of St Gobain, France. Several years elapsed before the mirror was delivered, and at the time of my visit the work of grinding, polishing, and figuring the disk was proceeding in Pasadena, where Mr Hooker had erected a building for the purpose. He gave me a letter of introduction to Dr Ellerman, who he said would gladly show me the great mirror.

Naturally I lost no time in presenting the letter, but on my arrival at the room where I was told Dr Ellerman would be found, I saw him deeply intent upon a small white globe on which he seemed to be inscribing some mathematical device. I stood in the doorway, uncertain whether to make my presence known or quietly disappear, for I had been warned by experience of the danger of disturbing a scientist when he is engaged upon a profound problem—when he looked up and saw me. I murmured something about hoping that I was not disturbing him. He laughed, and told me that he was writing his name on a tennis-ball! I then gave him Mr Hooker's letter of introduction and was shown over the building. In the polishing room was the great mirror, and my attention was called to a great circular object moving regularly and ceaselessly over the block

of glass, which is thirteen inches thick and weighs four and a half tons. It was two years before the polishing was completed, and I saw the great mirror again when it was tested in 1912, but the pleasure of looking at it in its present position in the tube of the great telescope still awaits me.

Dr Ellerman told me how anxious Mr Hooker was to hasten the work of polishing, as he hoped with his friend Mr Carnegie—the two great ironmasters—to see the task completed. Mr Hooker was 75 and Mr Carnegie was 76, which led Mr Carnegie to make the remark to Mr Hooker at their last meeting in Los Angeles: "Will it be in our day, John?"

The query was answered for Mr Hooker a few weeks after I met him, for he was taken suddenly ill and died on May 24th, 1911. It was answered later for Mr Carnegie. He too died before the giant mirror was set in its place.

Perhaps the most wonderful work of this mirror has been the measurement of the diameter of the giant star Betelgeux. This measurement has been made with the aid of an instrument called an interferometer, which may be simply described as follows:

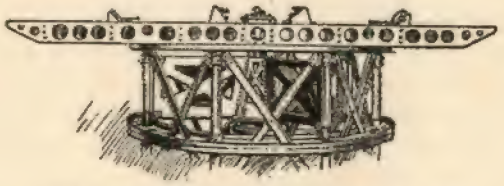
It consists of a steel girder, over twenty feet in length, attached to the upper end of the tube of the great 100-inch reflector. On the girder are mounted four mirrors, arranged in pairs. Each pair is so adjusted as to act somewhat after the manner of a trench periscope. The two outer mirrors, which receive light from the stars, can be moved in and out along the girder.

The following illustration of the interferometer is taken from a lecture to boys and girls given at the Royal Institution by Professor Turner during the Christmas vacation in 1922:

> An American astronomer has shown by a very clever device, how to use a telescope as though it were far bigger than it really is. He has taken into account the hammer-headed shark, a

marine creature shaped something like a T, with the eyes placed at the two extremities of the transverse head. By constructing a telescope on this plan, he has found it possible practically to increase the lens of the telescope from eight to twenty feet, and in this way one can measure the diameter of some of the largest stars.

Thus Betelgeux was reckoned to be four hundred times larger than our Sun, which is four hundred times larger than the Moon. (The diameter of the Sun is 865,000 miles.) Arcturus, that bright star in the constellation of Boötes, and easily found by following the curve in the three stars denoting the three horses in Charles' Wain,



THE INTERFEROMETER AT MOUNT WILSON

has a diameter of 21,000,000 miles; while Antares, the leading brilliant in the constellation of the Scorpion, is 400,000,000 miles in diameter.

So vast is the subject we have been reading together that the little we have learned from this book cannot do much more than impress us with our smallness. But if it has done that we may be satisfied, for knowledge begins when we realize that there is something about which it is worth while to try to learn more. And surely on a clear, starry night we shall feel a greater curiosity within us as we turn our eyes—keener of vision for what we have learned—to the great panorama stretched over our heads and fading into distances which are only the near shores of oceans—oceans which man could not span even with instruments as far beyond the power of the giant telescopes of to-day as these exceed the range of

the magic glass with which Galileo astonished the Venetians centuries ago.

We may in imagination see the heroes and the monsters with which the ancients peopled the heavens. Their vision was more limited, but they had the same curiosity, and as was their way they answered their own questions with fables. As they gazed upon the starry firmament they were stirred to a poetry which will never fail to move men to awe:

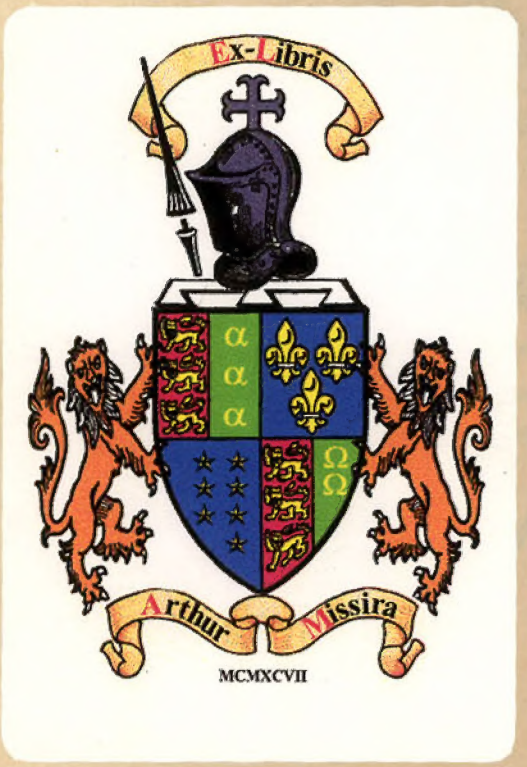
> The heavens declare the glory of God;
> And the firmament showeth his handywork.
> Day unto day uttereth speech,
> And night unto night sheweth knowledge.

These great words of the old Hebrew King remain ringing in our ears when we turn from our great telescopes and lay aside our books. So far may we go in penetrating the secrets of the Universe, but no farther, and the long ages of man's patient study and observation of the stars has taught him that in the ordered and majestic movements of the heavenly bodies is an intelligence as far above his own as the great flaming stars excel in size the tiny planet upon which his brief day is spent.

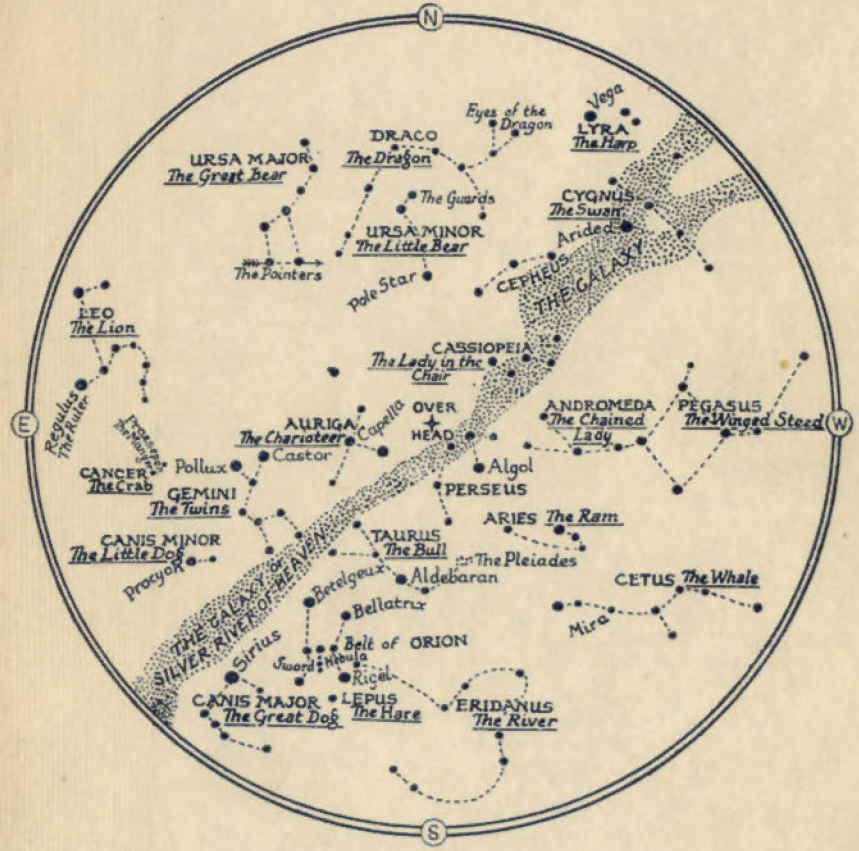
> When I consider thy heavens, the work of thy fingers,
> The moon and the stars, which thou hast ordained;
> What is man, that thou art mindful of him?

INDEX

Book of the Heavens



STARS VISIBLE IN AUTUMN



STARS VISIBLE IN WINTER-TIME

The Book of the Heavens

Mary Proctor

HARRAP